DRAFT

SAN FRANCISCO BAY AREA NETWORK
FRESHWATER QUALITY MONITORING PROTOCOL

Protocol Narrative

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REVISION HISTORY LOG

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	2-16-05	Mary Cooprider	Added stream miles table for GPRA goals, addressed comments from WRD on QA/QC, added SOP 1	Clarification of existing information, minor edits	1.01
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2.0	7-29-05	Mary Cooprider	Added abstract and maps; updated tables; incorporated comments from technical peer review	Finalizing draft for formal peer review	2.01

1. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, …etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz et al., 2002).

2. Notify the SFAN Lead Data Manager of any changes to the Protocol Narrative or SOP so that the new version number can be incorporated in the Metadata of the NPSTORET database. The Data Manager will then edit the database per any changes to the Protocol Narrative and SOPs.

3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOP.

Abstract

The National Park Service Inventory and Monitoring (I&M) Program measures long-term changes in the condition of natural resources throughout the National Park System. As part of this effort, the San Francisco Bay Area Network (SFAN), which encompasses Eugene O'Neil National Historic Site, Fort Point National Historic Site, Golden Gate National Recreation Area, John Muir National Historic Site, Muir Woods National Monument, Pinnacles National Monument, Point Reyes National Seashore, and the Presidio of San Francisco, has developed a detailed water quality monitoring plan. The plan consists of three sections: 1) a protocol narrative, 2) standard operating procedures (SOPs), and 3) supplementary materials. The *protocol narrative* summarizes the significance of aquatic resources in the SFAN with a focus on beneficial uses of freshwater streams. The narrative also discusses the SFAN waters listed as impaired under the Clean Water Act section 303d and describes associated Total Maximum Daily Load (TMDL) projects. The narrative defines the network's water quality criteria and monitoring questions and discusses the use of a rotating basin design and a decision table for selecting streams and monitoring sites. The protocol narrative addresses all aspects of data management and storage and provides an overview of water quality data analysis. Finally, the narrative discusses the expected program budget and personnel qualifications. Specific *SOPs* prescribe personnel training procedures, methods of protocol revision, field equipment preparations, quality assurance/quality control, data analysis and reporting, and monitoring site establishment. Additional SOPs address procedures for sampling specific parameters including core water chemistry (temperature, pH, dissolved oxygen, and conductivity), bacteria, nutrients, sediment, and streamflow. The protocol narrative and SOPs follow techniques outlined by the U.S. Geological Survey (USGS), the State Water Resources Control Board Surface Water Ambient Monitoring Program, and the U.S. Environmental Protection Agency's Western Pilot Study Field Manual for Wadeable Streams. *Supplementary materials* include a preliminary water quality status report for the SFAN, the USGS National Field Manual (on CD), and a USGS tutorial (on CD) for taking flow measurements. The comprehensive collection of information in the protocol narrative, SOPs, and supplementary materials is intended to standardize water quality monitoring and ensure that methods and data are comparable and effective in the long-term.

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LIST OF ACRONYMS AND ABBREVIATIONS USED

ASBS	Area of Special Biological Significance
AWAG	Alhambra Watershed Action Group, Martinez, CA
BMP	Best Management Practice
BO	Biological Opinion
BU	Beneficial Use
CALM	Consolidated Assessment and Listing Methodology (EPA)
CCCR	Central California Coast Biosphere Reserve
CCSF	City and County of San Francisco
CDFG	California Department of Fish and Game
COE	Army Corps of Engineers
CSRP	Coho and Steelhead Restoration Project
CWA	Clean Water Act
DDT	Dichloro-Diphenyl-Trichloroethane
DHS	California Department of Health Services
DMMO	Dredged Materials Management Office
DO	Dissolved Oxygen
EBRPD	East Bay Regional Park District
ENSO	El Niño Southern Oscillation
EPA	(United States) Environmental Protection Agency
EUON	Eugene O'Neill National Historic Site
FDA	(United States) Food and Drug Administration
FIB	Fecal Indicator Bacteria

LIST OF ACRONYMS AND ABBREVIATIONS USED (CONTINUED)

FOPO	Fort Point National Historic Site
GFNMS	Gulf of the Farallones National Marine Sanctuary
GMA	General Minerals Analysis
GOGA	Golden Gate National Recreation Area
GPRA	Government Performance and Results Act
HI	Headlands Institute
HUC	Hydrologic Unit Code
I&M	Inventory & Monitoring
IPM	Integrated Pest Management
IQR	Interquartile Range (statistical value)
MDL	Method Detection Limit
MMC	Marine Mammal Center, Sausalito, CA
MMWD	Marin Municipal Water District
MPA	Marine Protected Areas
MPN	Most Probable Number (of bacteria)
MQO	Measurement Quality Objective
MUWO	Muir Woods National Monument
NAWQA	National Water Quality Assessment (USGS Program)
NFM	National Field Manual (USGS)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPSTORET	National Park Service version of EPA's STORET database
ONRW	Outstanding Natural Resource Water
PCB	Polychlorinated Biphenyls
PINN	Pinnacles National Monument
PORE	Point Reyes National Seashore
PQL	Practical Quantitation Limit
PRBO	Point Reyes Bird Observatory
PRES	Presidio of San Francisco
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
SBWD	Stinson Beach Water District
SCCWRP	Southern California Coastal Water Research Project
SFAN	San Francisco Bay Area Network
SFEI	San Francisco Estuary Institute
SOP	Standard Operating Procedure
SSC	Suspended Sediment Concentration
STORET	Storage and Retrieval (EPA's Water Quality database)
TBAG	Tomales Bay Agricultural Group
TBSTAC	Tomales Bay Shellfish Technical Advisory Committee
TBWC	Tomales Bay Watershed Council
T&E	Threatened and Endangered Species
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load

LIST OF ACRONYMS AND ABBREVIATIONS USED (CONTINUED)

TSS	Total Suspended Solids
TTS	Turbidity Threshold Sampling
UCB	University of California-Berkeley
UCCE	University of California Cooperative Extension
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USGS	United States Geological Survey
UWP	Urban Watershed Project
WRD	Water Resources Division (National Park Service)
WTP	Water Treatment Plant

1.0 BACKGROUND AND OBJECTIVES

1.1 Introduction & Purpose

Ecosystem vital signs are key to the National Park Service's (NPS) Inventory and Monitoring Program (I&M). A vital sign is a physical, chemical, or biological component of the air, water, or land. It is rarely possible to monitor all components, or indicators, of ecosystem health; therefore, vital signs are chosen since they are the most representative of the ecosystem as a whole and/or are most critical to ecosystem function. A goal of NPS Vital Signs Monitoring is to report ecosystem status and trends and to document how much confidence there is in the results. A good summary of vital signs monitoring is provided in *An Overview of Vital Signs Monitoring and its Central Role in Natural Resource Stewardship and Performance Management* (Fancy, 2005). It states that:

> Knowing the condition of natural resources in national parks is fundamental to the National Park Service's ability to manage park resources. Vital signs monitoring is a key component in the Service's strategy to provide scientific data and information needed for management decision-making and education. Vital signs monitoring also contributes information needed to understand and to measure performance regarding the condition of watersheds, landscapes, marine resources, and biological communities.

Through the NPS I&M program, 270 national park units were organized into 32 networks. In order to improve efficiency and reduce costs, parks were organized into networks that share similar geographic and natural resource characteristics. These networks share funding and a core professional staff to conduct long-term ecological monitoring (Fancy, 2005). The San Francisco Bay Area Network (SFAN) includes Eugene O'Neill (EUON) and John Muir (JOMU) National Historic Sites in Contra Costa County, Fort Point National Historic Site (FOPO) and the Presidio of San Francisco (PRES) in San Francisco County, and Muir Woods National Monument (MUWO) and Point Reyes National Seashore (PORE) in Marin County. Golden Gate National Recreation (GOGA) is located in Marin, San Francisco, and San Mateo Counties. Pinnacles National Monument (PINN) is located southeast of Monterey in San Benito County. Figure 1.1 shows the location of each of the parks.

Freshwater quality monitoring was funded through a NPS Water Resources Division (WRD) initiative and was also recognized as significant at the network level. The significance of water resources within SFAN is reflected in the network's ranking of freshwater quality as 3rd among all of the potential vital signs identified and prioritized by the SFAN. Freshwater quality has *direct* impact on several other indicators including: marine water quality, stream threatened and endangered (T&E) species and fish assemblages, T&E amphibians and reptiles, riparian habitat, wetlands, and aquatic macroinvertebrates. Freshwater quality has *indirect* impacts on all plant and animal life as well as human consumption, recreation, and enjoyment (i.e., the intrinsic value of water). Much of what is on the land is transferred to water via surface runoff, subsurface flow, and base flow (groundwater). Therefore, not only is water quality an indicator of the health of aquatic systems, but it is an important indicator of overall ecosystem health.

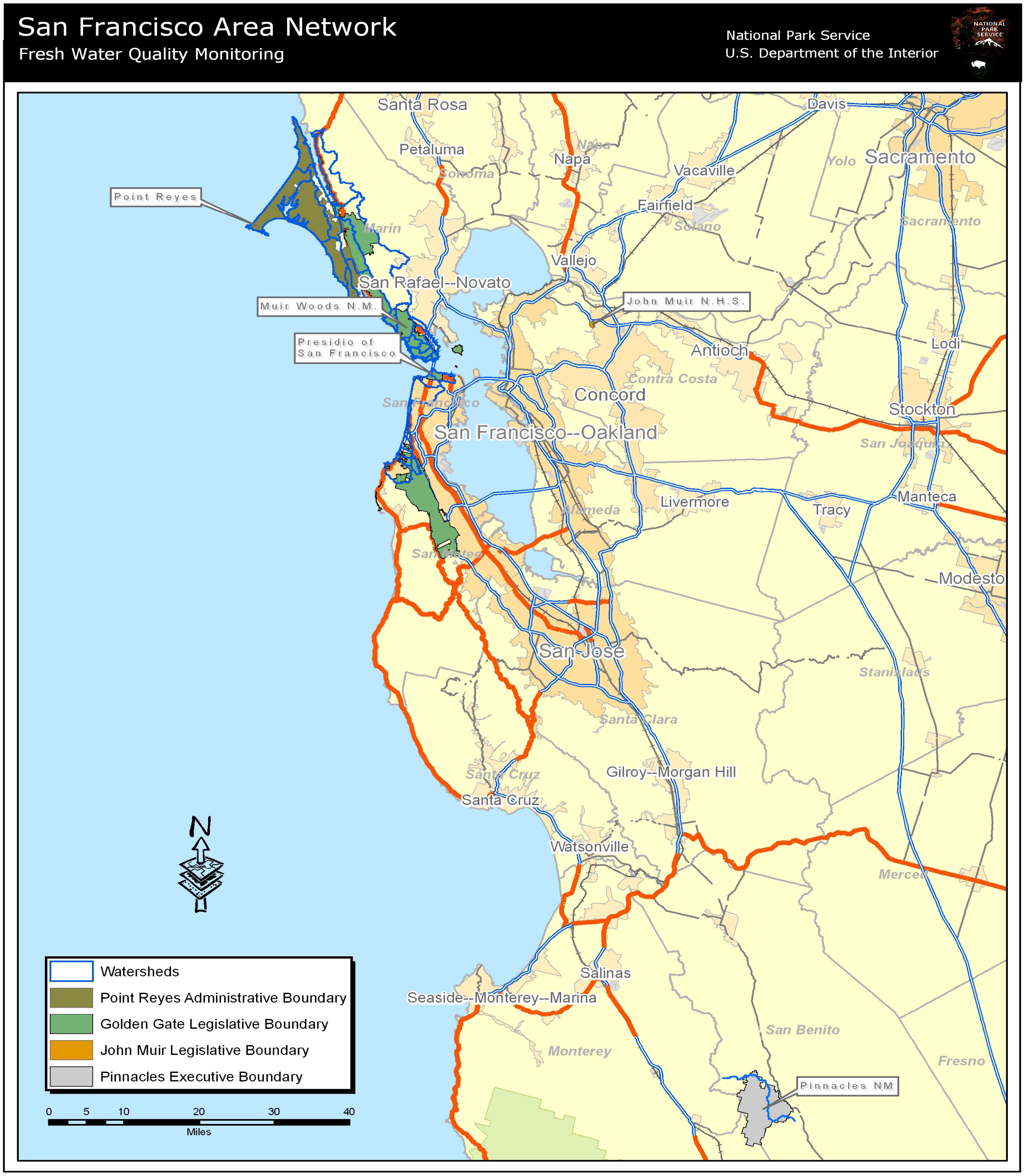

Figure 1.1. Map of San Francisco Bay Area Network Parks (created by Jason Herynk, National Park Service, 2005)

SFAN has many unique aquatic resources that are significant in an ecological and socio-economic context. Aquatic resources in the SFAN include streams, bays, estuaries, lagoons, lakes, reservoirs, freshwater and estuarine marshes, seeps, and springs. The combination of marine and freshwater aquatic systems within the network supports a variety of federal and state listed threatened and endangered aquatic species including the California freshwater shrimp (*Syncharis pacifica*), coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), the California red-legged frog (*Rana aurora draytonii*), tidewater goby (*Eucyclogobius newberryi*), Tomales roach (*Lavinina symmetricus ssp 2*), and northwest pond turtle (*Clemmys marmorata mormorata*). Commercial operations include a significant herring fishery in Tomales Bay and San Francisco Bay and oyster growing/harvesting in Tomales Bay and Drakes Estero. Oysters have not been commercially harvested in San Francisco Bay since 1910.

Watershed conditions vary from coastal watersheds in wilderness areas to an urbanized watershed managed as public water supply. Lobos Creek in the Presidio of San Francisco is the only free-flowing (above ground) creek in the city and is the public water supply for theh Presidio. Land uses within the more rural watersheds include agricultural and commercial operations (e.g., beef and dairy cattle ranching, vegetable farming, viticulture, oyster harvesting, and equestrian use) as well as predominantly wilderness areas.

The Mediterranean climate of the San Francisco Bay Region creates wet winters followed by dry summers. The resulting hydrology is flashy, with high runoff in the winter, and very low to intermittent flow dominating summer conditions. In response to flashy hydrologic conditions and the highly active geologic processes associated with the San Andreas Fault system, m ost stream channels are geomorphically dynamic. Chalone Creek in PINN includes a highly mobile sand bed that typically dries in the summer months. Watersheds within JOMU and the developed portions of GOGA are highly altered by development and urbanization. These systems are highly confined/constrained, with many natural processes engineered out of the stream systems. Within the Marin and San Mateo Counties portions of GOGA, as well as PORE, watersheds are fairly stable and support threatened coho salmon and steelhead trout. Although generally unaltered, stream systems in these areas have been impacted by historic and current agricultural activities as well as more dispersed development including roads and trails.

Several NPS efforts to improve water resources within SFAN are underway. The Redwood Creek watershed (GOGA/MUWO) is currently the focus of a variety of activities including watershed planning, transportation planning, water quality and water rights evaluations, sensitive species monitoring, aquatic system and riparian restoration, invasive non-native plant removal and habitat restoration, and GIS mapping of all watershed features. Similar activities are occurring throughout the network. Several stream restoration projects are on-going at PORE including bank stabilization, dam removal, and culvert removal projects. Restoration efforts for Chalone Creek (PINN) and its floodplain have also been initiated. Streambank restoration (including removal of invasive plants, erosion control, and bank stabilization) is proposed along Franklin Creek (JOMU), as well as a dam removal project in the Strentzel Creek (JOMU) watershed. Tidal wetland restoration efforts are on-going at PORE, GOGA, and PRES. Wetlands inventories and functional assessments are being conducted at GOGA (funded by the I&M program), as well as PORE (funding through NPS-WRD). In addition, a watershed project aimed at "daylighting" Tennessee Hollow Creek (PRES) and improving its ecological integrity is underway. Restoration efforts have primarily focused on the protection and restoration of natural physical processes, habitat known to benefit T&E aquatic species, and water quality.

The purpose of this Protocol Narrative is to address all of the significant issues that need to be considered when developing a long-term monitoring plan for freshwater quality. It documents the decision making processes involved in prioritizing streams, selecting sites, and selecting parameters to monitor and associated methods. The Protocol Narrative also provides a summary of monitoring methods, data management and reporting, and staff and budget considerations. This document provides a brief summary of SFAN water resources and an overview of water quality monitoring efforts. A more thorough review of surface hydrology and water resources, water quality monitoring efforts, and water quality issues and priorities is included in the "SFAN Preliminary Water Quality Status Report" (Cooprider, 2004). Details related to sampling methods, including safety and quality assurance/quality control (QA/QC) are included in individual Standard Operating Procedures (SOP) on each water quality parameter or group of parameters.

Many of the SOPs in the SFAN Freshwater Quality Protocol rely heavily on State and Federal protocols such as those published by the California State Water Resources Control Board (SWRCB), U.S. Geological Survey (USGS), and the U.S. Environmental Protection Agency (EPA). In most cases, when protocols differed among agencies, the State protocol was followed since they are most involved in monitoring on park lands. Other I&M network protocols were also consulted for consistency in protocol format and content. Ultimately, protocols were chosen based on the monitoring objectives. "Parks are encouraged to use or modify standard protocols and partner with existing programs wherever possible to allow comparability and synthesis of data at multiple scales, but the primary use of the data is at the park level for management decisions" (Fancy, 2005).

1.1.1 Beneficial Uses

All of the park units except PINN are regulated by the San Francisco Bay Regional Water Quality Control Board. There are nine Regional Water Quality Control Boards ("Regional Boards") that are part of the California State Water Resources Control Board, a unit of the California Environmental Protection Agency. Pinnacles NM is within the Central California Coast Regional Water Quality Control Board. Management criteria for water bodies within the state of California are established by the Regional Boards. Through their water quality control plans (also referred to as basin plans), the Regional Boards established beneficial uses for streams and set numeric and narrative criteria to meet those surface water use objectives.

The primary water quality issues within SFAN relate to whether or not streams are supporting the beneficial uses established by the Regional Boards. Table 1.1 includes the beneficial uses of all SFAN water bodies combined (streams, Pacific Ocean, etc). The beneficial uses of SFAN water bodies are numerous and this is a testament to the significance of water resources within the network. A list of beneficial uses for individual SFAN water bodies is included in Appendix A. The full definitions of beneficial uses are also included in Appendix A.

Table 1.1 Collective beneficial uses of SFAN water bodies.

Acronym	Definition
AGR	Agricultural Supply
COLD	Cold Freshwater Habitat
COMM	Commercial and Sport Fishing
EST	Estuarine Habitat
FRSH	Freshwater Replenishment
GWR	Groundwater Recharge
IND	Industrial Service Supply
MAR	Marine Habitat
MIGR	Fish Migration
MUN	Municipal Supply
NAV	Navigation
PROC	Industrial Process Supply
RARE	Preservation of Rare and Endangered Species
REC1	Contact Water Recreation
REC2	Non-contact Water Recreation
SHELL	Shellfish Harvesting
SPWN	Fish Spawning
WARM	Warm Freshwater Habitat
WILD	Wildlife Habitat

1.1.2 Water Quality Criteria

Water quality standards are key components of the water quality-based control program mandated by the Clean Water Act (CWA). Designated use classifications and numerical and/or narrative water quality criteria are two types of water quality standards. The CWA requires all States to establish use classifications for all waterbodies within the State. These beneficial uses were discussed in Section 1.1.1. Water quality criteria are numeric descriptions of the physical, chemical, and biological characteristics of waters necessary to support these designated beneficial uses.

The RWQCB Basin Plans include numeric and narrative water quality objectives for surface water. General water quality objectives for estuarine and marine waters are also included. However, a separate document, the Ocean Plan, was produced by the California SWRCB to regulate ocean waters (California State Water Resources Control Board, 2001).

Table 1.2 lists general numeric objectives for all inland surface waters, enclosed bays, and estuaries in the San Francisco Bay Area (San Francisco Bay Regional Water Quality Control Board, 1995). These general objectives can be used to determine whether water bodies are meeting specific beneficial uses. For example, un-ionized ammonia levels above the water quality objective would hinder the ability of a stream to support healthy aquatic life (e.g., fish spawning). This would then trigger a management action to reduce the inputs of nitrogen to the streams. It may also dictate more frequent sampling of nutrients, pH, and temperature – factors that affect the amount of ammonia in a stream.

Some of the water quality objectives for inland surface waters, enclosed bays, and estuaries within the Central Coast Regional Water Quality Control Board where PINN is located are slightly different than those listed in Table 1.2. For example, the numeric objective for pH is 7.0 to 8.5. The general objective for dissolved oxygen is $\geq$ 5.0 mg/L (Central Coast Regional Water Quality Control Board, 1998). However, for the specific beneficial uses COLD and SPWN, the objective is 7.0 mg/L.

Table 1.2 General numeric objectives for physical parameters in surface waters in the San Francisco Bay Area (San Francisco Bay Regional Water Quality Control Board, 1995).

Parameter	Water Quality Objective
Dissolved oxygen (tidal waters)	Downstream of Carquinez bridge: 5.0 milligrams per liter (mg/L) minimum Upstream of Carquinez bridge: 7.0 mg/L minimum
Dissolved oxygen (non-tidal waters)	Cold water habitat 7.0 mg/L minimum Warm water habitat 5.0 mg/L minimum
pH	Less than 8.5 and greater than 6.5
Un-ionized ammonia	Annual Median 0.025 mg/L as nitrogen (N) (freshwater) Maximum Central San Francisco Bay 0.16 mg/L (N) (estuarine)

Several other parameters that are important to the SFAN water qualitymonitoring program do not have ambient surface water quality objectives established by the Regional Boards. In these cases, Tables 1.3 and 1.4 can be consulted. Table 1.3 lists nutrient criteria and recommendations from several different sources.

The numbers are based on both human health criteria and overall aquatic health. Chronic human toxicity for nitrate occurs at 10 mg/L (San Francisco Bay Regional Water Quality Control Board, 1995). However, this may not be stringent enough for aquatic life (San Francisco Bay Regional Water Quality Control Board, 2003b). Chronic toxicity to aquatic life, especially fish and amphibian eggs, can occur at 1.1 mg/L (Kincheloe et al., 1979; Crunkilton, 2000). Nutrient levels at which algal growth limitation begins are less than 0.5 mg/L for total nitrogen and 0.1 mg/L for total phosphorus (Bowie et al., 1985).

Recent EPA criteria are based on *Ambient Water Quality Criteria Recommendations* for Ecoregions across the country (U.S. Environmental Protection Agency, 2000). A map of the ecoregions can be found at**:** http://www.epa.gov/waterscience/criteria/nutrient/ecomap.html**.** During the development of nutrient criteria for the ecoregions, several sources of data were consulted including historical and recent nutrient data and reference sites. Ecoregion III (Xeric West) covers PINN and JOMU while Ecoregion II (Western Forested Mountains) covers PORE and GOGA. Recommended criteria for Ecoregions II and III are listed in Table 1.3. These are not regulations but are intended to be "starting points" for states and tribes developing water quality standards (U.S. Environmental Protection Agency, 2000a). The EPA Ecoregion values in Table 1.3 represent nutrient levels that are generally protective of nutrient over enrichment. However, "States and Tribes should evaluate the information in light of the specific designated uses that need to be protected" (U.S. Environmental Protection Agency, 2000a). Conversely, overly stringent criteria may actually fall below levels of nutrient loading that naturally occur. The EPA encourages the states to develop more refined criteria through the use of local data.

There are also various recommendations for the sediment parameters total suspended solids and turbidity (Table 1.4). Randy Klein of Redwood National Park recommends comparing total suspended solids and turbidity data to several different thresholds (e.g., 25, 50, 100, 200, 500, 2000 NTU) (R. Klein, personal communication, 7 July 2005). Similarly, nutrient levels can be compared to several different thresholds until targets or Total Maximum Daily Loads (TMDL) are set. SFAN will utilize this "multiple thresholds" concept for data analysis. The effects of nutrients and sediment on water quality are discussed further in standard operating procedures in Appendix H.

Table 1.3 Recommended criteria for nutrients

Parameter	EPA Quality Criteria for Water (1986)	EPA Aggregate Ecoregion II Criteria (2000b)	EPA Aggregate Ecoregion III Criteria (2000a)	Kincheloe et al., 1979; Crunkilton, 2000	Bowie et al., 1985
Total Phosphorus (P)	0.1 mg/L	10 ug/L	21.88 ug/L		0.1 mg/L
Total Phosphates as P	50 ug/L				
Total Nitrogen		0.12 mg/L	0.38 mg/L		0.5 mg.L
Nitrate	10 mg/L			1.1 mg/L	

Table 1.4 Recommended criteria for sediment

	Sigler et al., 1984	Newcomb and Jensen, 1996	EPA Aggregate Ecoregion II Criteria (2003)	EPA Aggregate Ecoregion III Criteria (2003)
∗Acute Total Suspended Solids		> 50 mg/L		
∗Chronic (>6 days) Total Suspended Solids (TSS)		> 10 mg/L		
ϕTurbidity	25 NTU		1.30 NTU	2.34 NTU

∗Total suspended solids are listed in milligrams per liter (mg/L)
ϕTurbidity is listed as nephelometric turbidity units (NTU)

Only three beneficial uses within SFAN have specified bacterial objectives. These include contact recreation, non-contact recreation, and shellfish harvesting (Table 1.5). Many water bodies in SFAN meet the definition of non-contact recreation and some meet the definition for contact recreation (see Appendix A for complete list). The Regional Boards define contact recreation (REC1) as:

> Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs." Non-contact water recreation (REC2) is defined as: "Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where ingestion is reasonably possible. These uses include but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
>
> *San Francisco Bay Regional Water Quality Control Board, 1995*

Tomales Bay and Drakes Bay support shellfish harvesting. The State Department of Health Services (DHS) tests these waters for compliance with the National Shellfish Sanitation Program. Since the U.S. Food and Drug Administration (FDA) regulates shellfish consumption based on fecal coliforms, they are used instead of other fecal indicator bacteria (FIB) such as *Escherichia coli (E. coli).*

Table 1.5 Water quality objectives for coliform bacteria (*from* San Francisco Bay Regional Water Quality Control Board, 1995).

Beneficial Use	**Fecal Coliform (MPN/100mL)**	**Total Coliform (MPN/100mL)**
Non-contact recreation (REC2)	Mean < 2000 90^{th} percentile < 4000	
Shellfish harvesting (SHELL)	Median < 14 90^{th} percentile < 43	Median < 70 90^{th} percentile < 230

Additional detailed criteria specifically for contact recreation are relevant for SFAN lakes, freshwater lagoons, and some streams where swimming or other contact recreation occurs (Table 1.6). *Enterococcus* was added since it typically has greater survival in marine waters and is therefore a better indicator of fecal contamination in coastal areas. *E. coli* is used more frequently since analytical methods for this indicator are often more efficient and cost effective. Consecutive sampling (e.g., five consecutive weeks) to obtain a 30-day geometric mean is a necessary component of any monitoring scheme related to the REC1 beneficial use.

Table 1.6 U.S. EPA bacteriological criteria for contact recreation (REC1) in colonies per 100mL (*from* San Francisco Bay Regional Water Quality Control Board, 1995).

	Fresh Water
Total Coliform	
Single Day Sample	10,000
*30 Day Average	1,000
E. coli	
Single Day Sample	235
*30 Day Average	126
Enterococcus	
Single Day Sample	61
*30 Day Average	33
Fecal coliform	
Single Day Sample	400
*30 Day Average	200

* Geometric mean of five consecutive weeks

1.1.3 Significant Waters

Some water bodies have been specifically designated as significant due to a variety of factors including: biodiversity, ability to support a unique habitat or species, or status as relatively undisturbed. There are several significant and unique coastal waters within the San Francisco Bay Region. Recognizing the extraordinary significance and exposure to threats in the region, United Nations Educational, Scientific, and Cultural Organization (UNESCO) Man in the Biosphere program designated the Central California International Biosphere Reserve in 1988. This reserve encompasses six of the eight SFAN parks and includes coastal waters. The California coast is only one of five areas of eastern boundary coastal upwelling oceanic currents worldwide and the only one in North America.

The State Water Resources Control Board established Areas of Special Biological Significance (ASBS) in 1974. Five of these are within the legislative boundaries of the SFAN parks. These include the Point Reyes Headlands, Bird Rock, Double Point, Duxbury Reef, and the James Fitzgerald Marine Preserve. These areas were chosen through a nomination process based primarily on habitat quality and limited to coastal areas. The ASBS are all coastal areas since inland areas have not yet been assessed. Although this protocol focuses on freshwater quality, it is critical to know the significance of coastal "receiving waters" for the freshwater streams within SFAN. The procedure for this nomination process is outlined in the California Ocean Plan (2001) developed by the State Water Resources Control Board. A Southern California Coastal Water Research Project (SCCWRP) report to the State Water Resources Control Board addresses issues related to current and potential discharges into these ASBS (SCCWRP, 2003). In 2000, the California Department of Fish and Game drafted a Marine Protected Area (MPA) plan that proposed including ASBS as primary reserve areas. Maps of ASBS are in the appendix of the SFAN Preliminary Water Quality Status Report (Cooprider, 2004).

In addition to the above designations and associated marine protection, several marine sanctuaries are located offshore of PORE and GOGA. These include the Gulf of the Farallones National Marine Sanctuary, Cordell Bank National Marine Sanctuary, and Monterrey Bay National Marine Sanctuary. A plume of warmer freshwater exiting the San Francisco Bay extends out into the Gulf of the Farallones. These nutrient rich waters support an abundant and diverse fauna.

1.1.4 Clean Water Act Section 303d Impaired Waters

The EPA requires that States submit a list of waterbodies that fail to meet water quality standards. These lists are referred to as "303(d) lists" after the section of the CWA which contains the requirement. The EPA approves the list only if it meets applicable requirements. Waterbodies on an approved 303(d) list require the establishment of a total maximum daily load (TMDL). A TMDL specifies the amount of a particular pollutant that may be present in a waterbody, allocates allowable pollutant loads among sources, and provides the basis for attaining or maintaining water quality standards.

Water bodies within and adjacent to NPS lands have specifically been identified as impaired by the San Francisco Bay Water Quality Control Regional Board and in some cases, the EPA. Table 1.7 lists these water bodies. The Regional Board has established a timeline for development of Total Maximum Daily Loads (TMDLs) associated with the highest priority impairment listings (Table 1.8). Not all impaired (Section 303d listed) water bodies currently have TMDL projects. For a complete listing of impaired water bodies and a map of current projects see Regional Board's website at:
http://www.waterboards.ca.gov/sanfranciscobay/303dlist.htm

Sediment, Nutrients, and Pathogens

The San Francisco Bay Regional Water Quality Control Board has identified Tomales Bay and its tributaries Lagunitas Creek and Walker Creek as impaired by fecal coliform, sediment, and nutrients (Table 1.7). Health concerns have arisen due to contamination of shellfish with pathogenic bacteria. SFAN and PORE staff have collaborated with the Regional Board regarding monitoring of indicator bacteria in Olema Creek, a tributary to Lagunitas. The Regional Board recently completed a final TMDL project report for pathogens in Tomales Bay (San Francisco Bay Regional Water Quality Control Board, 2005). Implementation of monitoring (by NPS and others) for the Tomales Bay Pathogen TMDL program includes monthly monitoring plus five consecutive weeks of monitoring during both the winter and summer. NPS has also monitored sediment (total suspended solids and turbidity) and nutrients (nitrates and ammonia) in Olema Creek. Sediment and nutrient TMDL projects have not yet been completed for Tomales Bay (see Table 1.8 for completion dates). The Regional Board developed a conceptual approach for developing sediment TMDLs in San Francisco Bay Area streams (San Francisco Bay Regional Water Quality Control Board, 2003a). A conceptual approach was also developed for nutrient TMDLs in San Francisco Bay area water bodies (San Francisco Bay Regional Water Quality Control Board, 2003b). These reports provide background information about the pollutant and preliminary plans for monitoring.

A portion of the San Francisquito Creek watershed is located within GOGA's Phleger Estate in San Mateo County. This creek is listed as sediment impaired. The type and extent of impairment is unknown at this point. SFAN recently began baseline water quality monitoring (including sediment) in West Union Creek, one of the San Francisquito Creek tributaries.

Metals, Pesticides, and Other Chemicals

Tomales Bay is also listed as impaired by mercury due to an abandoned mercury mine in the Walker Creek watershed. In 2000, Marin County announced a fish consumption advisory for Tomales Bay due to mercury bioaccumulation. San Francisco Bay is also impaired by mercury. Current TMDL projects in the Bay include mercury and polychlorinated biphenyls (PCBs). Potential sources of mercury include industrial and municipal point sources, resource extraction, and atmospheric deposition. Sources of PCBs are unknown (non-point sources). Other pollutants listed by the Regional Board include exotic species and selenium; EPA has also added several pollutants to the list including the pesticides chlordane and dichloro-diphenyl-trichloroethane (DDT).

All urban creeks in the San Francisco Bay area are considered impaired by diazinon. Potential for contamination by this pesticide exists in all urban areas. The most urbanized areas within NPS lands include water bodies in the Presidio (Lobos Creek, Dragonfly Creek, Tennessee Hollow Creek), JOMU (Franklin Creek), and GOGA (Milagra Creek, Calera Creek, Sanchez Creek, San Pedro Creek). With the exception of the Presidio creeks, significant portions of these watersheds are located outside NPS land. City water treatment plants monitor diazinon; data is available from the Baker Beach Treatment Plant that tests Lobos Creek. Recent data from the treatment plant has not indicated contamination of Lobos Creek by diazinon. A *Final Project Report for Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks* was also completed by the San Francisco Bay Regional Water Quality Control Board (2004). More recently, the Regional Board has turned its focus to pyrethroid based pesticides since they are replacing the phased-out diazinon based pesticides. Information on pyrethroids in the San Francisco Bay Area can be found in *Pesticides in Surface Water: Annual Research and Monitoring Update 2005* (TDC Environmental, 2005).

Table 1.7 Impaired water bodies in the SFAN

Waterbody (Watershed)	Park Unit	Pollutant
Coyote Creek (Richardson Bay)	GOGA	Diazinon
Lagunitas Creek (Tomales Bay)	PORE, GOGA	Pathogens, Sediment, Nutrients
Richardson Bay*	GOGA	High Coliform, Mercury, PCBs, Pesticides, Exotic Species
San Francisco Bay*	GOGA, PRES	Mercury, PCBs, Nickel, Pesticides, Exotic Species, Dioxin, Selenium
San Francisco Bay Urban Creeks	GOGA, PRES, JOMU	Diazinon
San Francisquito Creek (SF Bay)	GOGA	Diazinon, Sediment
San Pedro Creek (Pacific Ocean)	GOGA	High Coliform
Tomales Bay	PORE, GOGA	Pathogens, Sediment, Nutrients, Mercury

*See Appendix A of the *SFAN Preliminary Water Quality Status Report* (Cooprider, 2004) for details on pollutants

Table 1.8. San Francisco Bay Regional Water Quality Control Board TMDL Project Timeline as of June 2005

Water body	Park Unit	Pollutant	Project Report Completion	Regional Board Adoption Date
San Francisco Bay	GOGA, PRES	Mercury	June 2003	Sept. 2004
San Francisco Bay	GOGA, PRES	PCBs	Nov. 2003	Sept. 2005
Tomales Bay	GOGA, PORE	Pathogens	Feb. 2004	Mar. 2005
SF Bay Urban Creeks	GOGA, PRES, JOMU	Diazinon	Mar. 2004	June 2005
San Francisco Bay	GOGA, PRES	Nickel	Dec. 2004	Aug. 2005
San Francisquito Creek	GOGA	Sediment	Dec. 2005	Dec. 2006
Tomales Bay	GOGA, PORE	Mercury	Aug. 2006	Dec. 2007
San Francisco Bay	GOGA, PRES	Pesticide Toxicity	Oct. 2006	Aug. 2007
Lagunitas Creek	PORE, GOGA	Sediment	Dec. 2006	Feb. 2008
San Francisco Bay	GOGA, PRES	Legacy pesticides	Dec. 2007	Dec. 2008
Tomales Bay	GOGA, PORE	Sediment	Dec. 2007	Dec. 2008

1.1.5 Water Quality Monitoring History

A summary of water quality issues, monitoring activities, and data is provided in the *SFAN Preliminary Water Quality Status Report* (Cooprider, 2004). Section 1.1.5.1 below provides a s summary of water quality issues. Refer to the water quality status report for a review of hydrology and location water bodies in the network. SFAN parks and waterbodies are in various stages of monitoring. While some watersheds are in need of comprehensive baseline data, others are in need of more strategic data focused on suspected pollution sources. A summary of water quality monitoring activities for the major water bodies within the network is included in a table in Appendix B.

1.1.5.1 SFAN Land Uses and Related Water Quality Issues

Golden Gate NRA (GOGA) and Muir Woods NM (MUWO)
Muir Woods NM is located within the legislative boundary of GOGA. Therefore, although the two parks were established separately (i.e., by different enabling legislation), they are often included together. In addition, MUWO is located entirely within the Redwood Creek watershed and GOGA encompasses much of the lower part of this watershed. GOGA manages a large area but very few complete watersheds. Many of the lands have been managed and altered through agricultural and military uses. Due to the size and nature of the park including high visitor use, proximity to the urban interface, and multitude of recreation and land uses, there are several water quality related issues. Accelerated erosion due to roads, trails, and other uses and developments threatens the sediment balance and ecological health of several watersheds. Cattle grazing is no longer allowed on GOGA managed lands (National Park Service, 1999) but some of the impacts remain. Bacteria and nutrient inputs from equestrian operations, pet waste, agricultural operations, sewer and septic systems can impact wildlife and public health as well as the overall ecological balance of water resources. Channel alteration such as dams and culverts impacts the ecological health of park watersheds. Many park water quality issues are related to facilities and structures. Water quality issues occur to varying extents within multiple park watersheds.

John Muir NHS (JOMU)
Potential or existing issues in the JOMU sub-watersheds include impacts of flooding and pollution by fecal coliforms, nutrients, and sediment. Potential sources of pollutants in Franklin Creek include illegal garbage dumping (including appliances, tires, etc.), highway runoff, equestrian operations, a nursery, and residential septic systems. Due to excessive erosion and the associated reduction of channel capacity, flooding frequently occurs in the Strentzel Lane neighborhood adjacent to the park and erosion is a major concern at the John Muir gravesite within JOMU.

Pinnacles NM (PINN)
Pinnacles NM shares some of the same water quality issues as other SFAN parks; however, due to drier conditions, groundwater issues are a proportionally larger concern at PINN than the coastal parks. Reduction and contamination of groundwater and

elevated levels of sediment, bacteria, and nutrients in surface waters are current issues. Due to past land uses (particularly a former landfill site), threats of heavy metal contamination are also a concern. Some of these concerns are not well documented; therefore, one goal of a long-term monitoring plan is to clearly identify threats to water quality in order to better understand the extent of contamination so that it can be addressed.

Point Reyes NS (PORE)
There are several water quality issues within PORE. These issues relate to the beneficial uses of fish migration and spawning, shellfish harvesting, and contact recreation. Sediment, pathogens, and nutrients are the most significant issues which can affect these beneficial uses. Erosion due to the presence of a major earthquake fault, cattle grazing, roads, culverts, and trails threatens the sediment balance and ecological health of several watersheds. Excess sediment has detrimental effects on salmonids including clogging of gills, embedding of gravel beds used for spawning, and inability to locate food sources. Due primarily to the significant acreage of pastoral land within park boundaries, bacterial contamination is also a very serious and prevalent issue. Bacteria inputs are primarily dairy and beef cattle operations, but pet waste, particularly at beaches, stable operations, and septic systems may also be contributing.

Presidio of San Francisco (PRES)
Freshwater quality issues within the Presidio are related to pesticides, other chemicals, landfills, hazardous waste, heavy metal contamination, nutrient inputs, public health (contact recreation), sanitary sewers, and storm drains. One of the main threats to Lobos Creek is leaky storm and sanitary sewer lines that cross the creek. There is also a landfill above the source of Lobos Creek. Ground disturbance and contamination are potential issues with this landfill. Lobos Creek also has had high bacteria numbers at the Baker Beach outfall. Warning signs have been posted at Baker Beach due to water samples exceeding the criteria for contact recreation. Heavy metal contamination problems are prevalent throughout the Presidio; metals are mainly a concern in sediments. At Mountain Lake high levels of lead have been found in the sediments. Remediation plans are underway to address the sediment contamination issue. Also, nutrients from waterfowl waste have caused excessive algal growth in lake.

1.2 Rationale for Selecting this Resource to Monitor

Freshwater quality has high ecological, management, and legal significance within SFAN parks. Freshwater systems within the network support a variety of threatened and endangered species including California freshwater shrimp (*Syncharis pacifica*), coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), California red-legged frog (*Rana aurora draytonii*), and northwest pond turtle (*Clemmys marmorata mormorata*). Beneficial uses of freshwater bodies include contact recreation and non-contact recreation, fish spawning, agricultural water supply, and wildlife habitat (see Section 1.1.1). Some streams do not support, or only partially support, these beneficial uses due to impairment. For watersheds that are located primarily on parklands, significant tangible management actions can be taken to improve water quality of these impaired streams. Implementation of this monitoring protocol will provide park management with the data necessary to make effective decisions to ameliorate poor water quality and maintain good water quality of SFAN water bodies.

1.2.1 Measurable Objectives

1. Determine the long-term trends in water temperature, pH, conductivity, dissolved oxygen, fecal and total coliforms, nitrate, ammonia, and total nitrogen at selected sites in priority streams within SFAN.

2. Determine the existing ranges and diurnal variability of water temperature, pH, conductivity, and dissolved oxygen at selected sites in priority streams within SFAN.

3. Determine the extent that priority streams within SFAN meet federal and state water quality criteria for fecal indicator bacteria, un-ionized ammonia, dissolved oxygen, and pH.

4. Determine whether priority SFAN streams meet recommended criteria or established thresholds for total nitrogen, nitrate, turbidity, and suspended sediment.

Specific thresholds or trigger points for chemical and biological parameters are listed in Section 1.1.2 (Water Quality Criteria). These numeric objectives will be used to determine when waters are outside their natural range and whether or not they meet federal and state water quality criteria.

The list of impaired miles of water bodies in Table 1.9 is taken from the NPS Water Resources Division (WRD) website http://www1.nrintra.nps.gov/wrd/dui/. It is based on a GIS coverage of the Section 303d listed water bodies. It is important to note that tributaries of listed water bodies are also impaired even though the tributaries themselves may not be listed. Tributary miles are not included in the table. In addition, PORE manages the north district GOGA lands that include the impaired Lagunitas Creek.

Table 1.9 Stream and shoreline miles of impaired waters within SFAN

	Total Stream Miles (intermittent/ perennial)	303(d) Impaired Miles	Lakes and Reservoirs Acres	303(d) Impaired Acres	Sea/Ocean Shoreline Miles	303(d) Impaired Shoreline Miles
FOPO	0	0	0	0	0.37	0.37
GOGA	187.12	20.42	1869	0	93.24	46.70
JOMU	0.28	0	0	0	0	0
MUWO	2.14	0	0	0	0	0
PINN	90.98	0	4.24	0	0	0
PORE	101.55	0	544.06	0	101.01	15.67
PRES	0.71	0	5	0	3.2	3.2

1.2.2 Overall Monitoring Questions

- What are the existing chemical and biological ranges in water quality within SFAN streams?
- What are the long-term trends in water quality in SFAN streams?
- Is the water quality of SFAN streams in compliance with designated beneficial uses?
- What are the point and non-point pollution sources within the watersheds?
- Are specific management actions reducing pollution loads?

Specific monitoring questions for each site and parameter are discussed in Chapter 2 (Sampling Design). Questions will also be augmented and refined during the protocol testing phase. Also, as this protocol is implemented it will become more clear what the I&M program can provide to park managers and what specific issues the parks may need to address individually. In other works, the I&M program will help provide a link between broad monitoring and source differentiation/efectiveness monitoring for management practices. For source differentiation a longer time period and greater sampling frequency is needed. The I&M program can make recommendations to park management but may not necessarily cover all source differentiation monitoring from a budget and staff perspective.

1.2.3 Other Regional Water Quality Monitoring Programs

Within the SFAN, several monitoring programs have existed or are on-going. Water quality programs developed by the parks include a comprehensive (i.e., parkwide) water quality monitoring program at PORE and stables and stormwater monitoring projects at GOGA. Other NPS monitoring programs include the Coastal Wetland Restoration at Lower Redwood Creek (GOGA), Giacomini Marsh (PORE/GOGA), and Crissy Marsh (PRES). The *SFAN Preliminary Water Quality Status Report* provides a more thorough review of the monitoring conducted by NPS staff (Cooprider, 2004).

Several other agencies are monitoring aquatic resources (water quality, stream flow monitoring, fish) within SFAN watersheds. The Tomales Bay Watershed Council (for which NPS staff participate and provide technical expertise) has developed a water quality monitoring plan for their watershed which includes PORE and GOGA lands. The I&M water quality monitoring protocol will be implemented, where possible, in conjunction with the Tomales Bay Watershed Council's Water Quality Monitoring Plan. Other agencies associated with SFAN watersheds, either through water quality monitoring or land management activities include:

Alhambra Watershed Action Group (AWAG)
California Department of Fish and Game (CDFG)
California Department of Health Services (CDHS)
California State Parks
(California) State Water Resources Control Board
City and County of San Francisco (CCSF)
Contra-Costa County
County of Marin
Friends of Alhambra Creek
Headlands Institute
Marin County Resource Conservation District (RCD)

Marin Municipal Water District (MMWD)
Muir Beach Community Services District (MBCSD)
San Francisco Bay RWQCB Surface Water Ambient Monitoring Program (SWAMP)
San Francisco State University (SFSU)
San Francisquito Creek Watershed Council
San Jose State University (SJSU)
Salmon Protection and Watershed Network (SPAWN)
Stinson Beach County Water District
Tomales Bay Agricultural Group (TBAG)
Tomales Bay Watershed Council (TBWC)
University of California-Berkeley (UCB)
University of California Cooperative Extension (UCCE)
University of San Francisco (USF)
Urban Watershed Project (UWP)
U.S. Geological Survey (USGS)

1.3 Measurable Results and Deliverables

Data will be summarized annually by the water quality specialist and every three to five years to evaluate trends and to conduct more intensive data analysis. Reports will be provided to each park unit and the I&M coordinator. A completed NPSTORET database as well as a summary report will be provided to the NPS Water Resources Division (WRD) in Fort Collins annually. In the more detailed trend report, recommendations will be provided to parks regarding management actions to improve water quality including any additional monitoring that the individual parks could conduct (efforts outside the means or scope of the I&M monitoring program).

The SFAN aquatics group, consisting of water resources professionals from all of the SFAN parks, as well as the Network Coordinator will meet quarterly to discuss progress and provide guidance for the freshwater quality monitoring program. More formal water quality planning meetings catering to park management staff will be held during the summer. These meetings will include a discussion of water quality monitoring results for each park and will provide a forum for discussing and recommending management practices related to water quality issues. These meetings will also provide an opportunity to receive suggestions on refining protocols. In addition, the meetings will help foster a relationship between I&M program staff and park staff to ensure that parks obtain needed data and feedback, and that the I&M program receives necessary information and support form parks.

2.0 SAMPLING DESIGN

2.1 Rationale For Selecting This Sampling Design Over Others

An appropriate sampling design ensures that specific monitoring questions will be answered with the data gathered and the subsequent statistical analysis. A sampling design needs to enable us to detect changes that are statistically significant and ecologically significant although these are not always identical (Irwin, 2004). The process of developing an overall statistical sampling design requires a knowledge of management objectives, associated monitoring objectives (Ch.1), and specific monitoring questions. A logical process for developing specific monitoring questions is: 1) Develop monitoring questions for each objective, 2) Determine site locations based on monitoring questions, 3) Determine specific questions for each site location, and 4) Determine specific questions for each parameter.

2.1.1 Sampling Design Types

One approach to sampling design suggests three options for monitoring designs (EPA, 2002). These options include *census* (monitoring every water body), *judgmental* (specific water bodies and locations are targeted based on what is known), and *statistical surveys* (probability-based). EPA's Environmental Monitoring and Assessment Program (EMAP) utilizes probability sampling.

States will often utilize more than one sampling design to meet monitoring objectives but they do not typically use census monitoring. However, monitoring all waters of a particular type (e.g., recreational waters) is sometimes utilized. Although not commonly used, many states are adding some component of probability-based surveys to their monitoring programs. These designs "ensure that sample units represent the target population and are statistically unbiased" ((U.S. Environmental Protection Agency, 2002). However, judgement is a major component of any water quality monitoring design and most states primarily utilize judgmental (non-random) designs that are focused on answering a specific management question. The USGS National Water Quality Assessment (NAWQA) program is an example of a judgmental (i.e. targeted) design (U.S. Environmental Protection Agency, 2002).

Other sampling designs include a *rotating basin* component targets certain basins in a state for intensive and/or probability-based monitoring. The basins that are monitored change each year so that over a period of time (typically five years), the entire state is monitored (e.g., all lakes in the state). *Fixed station* networks monitor the same sites over a long period of time. These are often used to establish long-term trends in water quality at these sites. *Intensive survey* designs incorporate a large number of sites in an area (e.g., a watershed) for a specified period. This design may take the form of an intensive basin/watershed survey or a site-specific study. These designs may be used in conjunction with each other.

2.1.2 Sampling design for the SFAN

Previously, parks within the SFAN have typically utilized judgmental designs for short-term projects (e.g., before and after a restoration project or implementation of a management practice) or source differentiation. Due to the proximity of water bodies to stables and dairies, monitoring has consisted largely of source differentiation rather than baseline or trend data. In addition, sampling has been opportunistic, rather than scheduled, in order to capture pollutant loads during storm events. However, more recent monitoring efforts have centered around scheduled sampling events with some flexibility built in for storm sampling. Judgmental design will continue to be used in the long-term because 1) all of the SFAN parks have used this and many sites have already been monitored in the past, 2) the SFAN watersheds are relatively small and therefore don't lend themselves to large randomization schemes, 3) sites can be co-located with monitoring sites for other vital signs, and 4) limited funding, and 5) often more useful for park management.

Potential water quality monitoring sites for a judgmental design include: 1) where a stream leaves the park, 2) where a stream enters the park, 3) upstream control sites near the source, 4) the mouth of a stream or tributary, and 5) upstream and downstream of known pollutant sources. Existing programs, such as the pathogen TMDL monitoring required by the RWQCB, have utilized similar site selection processes. The result is that sites in the upper, middle, and lower reaches are included. If a random design were implemented, streams would most likely be stratified into upper, middle, and lower reaches and sites would be similar to existing monitoring sites or those chosen for the long-term monitoring plan.

Drawbacks to a judgmental design are that assumptions are made regarding the stream locations and their relative levels of pollutants. For example, we generally assume that the most upstream site, the control site near the stream sources, is probably the most natural site since there are fewer opportunities for contamination. We also assume, based on knowledge of past data, that we know where the most polluted sites or sources are. Randomization does not make assumptions and could potentially help in determining or discovering more or less polluted sites than those chosen based on assumption.

Although site selection will primarily be judgmental, elements of randomness will be added at various design levels. For example, even though the selection of target streams and sites was not probabilistic, the particular pool or riffle that is sampled can be chosen randomly if more than one pool or riffle is present. The type of habitat sampled differs based on the type of stream (perennial or intermittent) and the monitoring questions. In addition, the sampling spot within the habitat can also be chosen randomly. Temporal randomization (ie., sampling at different times of the day) is another strategy for adding randomization to a sampling design. However, the SFAN water quality specialist will follow the same site order for each sampling event with the idea of sampling at approximately the same time every day for each site. Some parameters such as dissolved oxygen and pH can vary significantly within a 24 hour period. This will be discussed further in the SOPs.

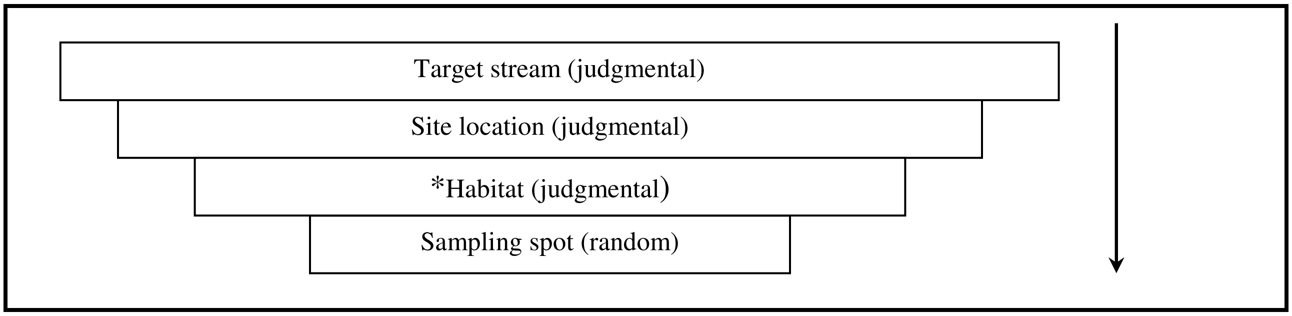

Figure 2.1 Levels of sampling design and associated degrees of randomness.

*Note: In situations where there is more than one pool or riffle, the specific pool or riffle to be sampled will be chosen randomly.

A rotating basin scenario will be implemented in order to monitor the maximum number of waterbodies of concern. The number of streams rotated and the rotation interval will depend on funding and staff constraints. This would enable monitoring of more water bodies on a fixed budget. It also allows sufficient time for comprehensive water quality data reporting. USGS NAWQA protocols recommend a minimum of two years of consecutive monthly monitoring (Gilliom et al., 2001) for rotating basin designs. A phasing-in approach (gradually adding more watersheds over time) will also be considered depending upon funding. This would allow longer-term data sets for trends, without two-year gaps. It also allows time to explore additional funding opportunities, partnerships, and ways of streamlining the monitoring program and enabling it to be more comprehensive.

2.2 Site Selection

2.2.1 Identification of Target Population, Study Boundaries, & Sample Units

For the SFAN, the target population of measurements is from a select group of water bodies. The EPA's Consolidated Assessment and Listing Methodology (CALM) provides examples of stratification for rivers/streams, lakes, wetlands, and estuaries (EPA, 2002). Rivers/streams are stratified into intermittent, wadeable, and non-wadeable/deep river. Most streams within the SFAN fall into the categories of intermittent and wadeable with a few ephemeral streams. Ephemeral drainages are not typically monitored since they are only flowing during storm events and the SFAN hydrologic systems are very flashy. These types of drainages are also often hidden in deep brush (including poison oak) and/or located on steep or otherwise difficult to access terrain. The sampled population for the SFAN, at least for the first five years of protocol testing and refining, will primarily include wadeable and intermittent streams within target watersheds. For the purposes of this monitoring plan, these are streams that are safely wadeable except in heavy storm or flood conditions. The target population is all possible values in a specified habitat (pool, riffle, or run) at a specific time (morning or afternoon) from a prioritized list of target watersheds.

Additional surface water strata (e.g., lagoons, lakes, marshes) may be added as protocols are updated and refined, and as funding permits. Although wetlands and marine/estuarine waters are significant resources within the SFAN, they are not included as target water bodies yet since these indicators were lower priority for the SFAN. However, protocols will be developed in the future as funding permits. All Areas of Special Biological Significance (ASBS) within the SFAN are in coastal waters and will be covered in a protocol for marine water quality.

2.2.1.1 Data representativeness/sampling constraints

There are physical constraints to sampling as well as data representativeness constraints and, in some cases both constraints are the same. To help ensure that inferences from a sample site (sample population) to a watershed (target population) are appropriate, continuous monitors will be deployed. Data from these instruments will help gain an understanding of seasonal and diurnal (daily) variability. These types of variability occur in many water quality parameters and will be discussed in greater detail in subsequent versions of this protocol and in the SOPs.

Some constraints to sampling representatively include difficult or unsafe access, particularly during storm events. Also, due to laboratory closures and lack of staff availability during the winter holidays when major storm events often occur, valuable water quality data may not be captured. Other constraints to sampling representatively are that sites will primarily be located within park boundaries and will not necessarily represent the larger watershed. This will not be a significant concern for the SFAN since parks encompass several watersheds in their entirety. However, watersheds with significant portions located outside park boundaries may not be sampled in some cases due to access issues, relative lack of management options, or other limitations.

2.2.1.2 Selection of target streams

The SFAN watersheds are identified and described in the San Francisco Area Network Preliminary Water Quality Status Report (Cooprider, 2004). The target population was chosen based on: 1) Data trends from review of WRD Water Quality Data Inventory and Analysis Reports and a UC Berkeley report (Stafford and Horne, 2004) including recent data from PORE, GOGA, and PINN, 2) Results of water quality planning meetings in 2002 and 2003, and 3) Decision Table (Appendix C) for the SFAN Target Water Bodies.

The decision table in Appendix C provides the major information needed to prioritize target watersheds. This prioritization is essential to reducing the number of water bodies monitored due to staff, time, and funding constraints. The table takes into account Category 1 and 2 waterbodies as defined by the NPS Freshwater Work Group Subcommittee (Rosenlieb et al., 2002). Category 1 waterbodies are listed as impaired by the Clean Water Act Section 303d. Category 2 waterbodies have one or more of the following characteristics: lack baseline data, have an established threat, are subject to ecological impairment or are linked to another vital sign (e.g., stream T&E and fish assemblages). Other characteristics used to prioritize target water bodies include a high proportion of the watershed within park boundaries (higher priority) and whether other entities are monitoring a particular water body (lower priority).

There are three levels of prioritization: high, medium, and low priority. Category 1 (303d listed) waterbodies are high priority for monitoring followed by water bodies having two or more of the Category 2 characteristics. Low priority water bodies have only one or none of the Category 2 characteristics. Medium priority water bodies often had a combination of characteristics Water bodies generally excluded from the priority list have one or more of the follow characteristics:

<u>Only listed as impaired by diazinon (no other Category 1 or 2 characteristics):</u>
The San Francisco Bay Regional Water Quality Control Board listed all San Francisco Bay Area urban streams as impaired by diazinon. These creeks are not specifically listed by name and it has not been verified that all of these streams contain elevated levels of diazinon. However, all urban creeks are considered to be potentially impaired by diazinon and are automatically included. Many SFAN streams (Franklin, Lobos, Dragonfly, Tennessee Hollow, Milagra, Calera, Sanchez, and Coyote Creek) are included.

Diazinon has now been phased out as a commercially available pesticide. Consequently, pyrethroid based pesticides have replaced diazinon as the Regional Board's primary pesticide of concern. Pesticides are not currently monitored in park streams but planning is underway to address pesticide issues through the WRD Level 1 Inventory Project. The SFAN is currently coordinating with the USGS to conduct baseline monitoring for pesticides in these urban creeks.

<u>Lacking baseline data:</u>
Water bodies that lack baseline data are not appropriate for Water Quality Vital Signs funding since there is separate funding through WRD for Level 1 Water Quality Inventory Program (R. Irwin, personal communication, 18 September 2004). Also, streams that lack baseline data are often lower priority for park management. This is illustrated by the fact that many of the streams lacking baseline data are not subject to ecological impairment. After baseline data is obtained for these water bodies, they will be added to the protocol if results indicate that there is an established threat.

<u>Streams primarily located off parklands:</u>
Water bodies with only small portions on park property are often located in urban areas where local watershed groups are active. This greatly improves the potential for parks to work with volunteers who, in many cases, are already been conducting monitoring activities. This also includes waterbodies that are located within the park legislative boundary but not managed by the park (and particularly areas where NPS staff access is restricted).

<u>Adequate monitoring by other entities:</u>
Water bodies consistently monitored by other entities (e.g., Stinson Beach County Water District monitors Easkoot Creek (GOGA)) need not be monitored. It is appropriate and fiscally responsible not to monitor these streams if the parks have access to the data and the data meets the needs of the monitoring program.

To provide an example of how the decision table and the above exceptions can be used to prioritize water bodies, consider Haggerty Gulch. It flows into Tomales Bay, a Section 303d water body. However, it is primarily located off parklands. In addition, it lacks baseline data and may qualify for a separate monitoring program through WRD.

Franklin Creek has some conflicting characteristics in the decisoin table. It has several low priority characteristics including: 1) only a small portion located on parklands, 2) only diazinon impaired, and 3) a local group conducting monitoring. However, it also has some high priority characteristics including 1) it has an established threat (high fecal coliform) and 2) is linked to the freshwater dynamics (stream hydrology) vital sign. It is also a highly visible resource for the park since it is located behind the John Muir historic house.

Strentzel Creek has a somewhat more complex set of decision-making factors. It is ephemeral, only half of the watershed is located on NPS property (JOMU), and it lacks baseline data. These are factors that would exclude it from the priority list. However, it is subject to ecological impairment and it is the only significant watershed within JOMU. Also, erosion and sedimentation in this watershed are highly significant management issues for that park. Therefore, it is included on the priority list. Strentzel Creek is actually a higher priority for JOMU than Franklin Creek since JOMU owns half of this small watershed and manages only a few hundred meters of Franklin Creek. However, because of the proximitiy of these two streams it makes sense to monitor both if possible. Strentzel Creek is ephemeral and there may be opportunities to coordinate local volunteers to monitor water quality (particularly sediment) during storm events.

West Union Creek is also a complex example of utilizing the decision table. The stream is only partially located on parklands but in this case, that does not reduce its priority since the headwaters are located on parklands. Also, the San Francisquito Creek Watershed Council and other groups are monitoring the creek further downstream but data is very limited for the upstream portion of the creek on parklands. Reasons to include it as priority stream in this monitoring plan are that it has a vital signs link (supports salmonids and possibly California red-legged frogs) and is subject to ecological impairment from erosion, landslides and potentially high coliform levels from equestrian use. It is also located within the sediment impaired San Francisquito Creek watershed.

The examples above illustrate the point that the decision table provides a significant amount of information to guide decision making but it is not always straightforward. The purpose of the decision table is to guide decision making through a review of all issues that need to be considered and to document the decisions. Despite efforts to categorize water bodies and follow a logical process, professional judgment and park management also play a role and the decision making process can be complex. The SFAN Preliminary Water Quality Status Report provides information about water quality priorities for each park (Cooprider, 2004).

The proposed priority water bodies were primarily chosen because they have an established threat and link to another vital sign. Olema Creek and Lagunitas Creek are also heavily weighted since they are considered impaired and this has been verified by baseline data. Chalone Creek is the only watershed within PINN. Additional (alternative) streams are those that have established threats (i.e., monitoring has shown high levels of pollutants) or are subject to ecological impairment (i.e., streams are suspected to be contaminated in the future) but are primarily priority for individual parks. Alternative streams could potentially be monitored if funding were available.

Table 2.1 High priority streams

Stream	Park
Lower Redwood Creek and tributaries (Green Gulch, Kent, Banducci, Camino del Canyon)	GOGA MUWO
Upper Redwood Creek and tributaries (Bootjack and Fern Creek)	GOGA MUWO
Rodeo Creek and tributary (Gerbode Creek)	GOGA
Tennessee Valley Creek	GOGA
Chalone Creek and tributaries (Sandy Creek, McCabe Canyon, Bear Gulch)	PINN
Olema Creek and tributaries (John West Fork, Davis Boucher Creek)	PORE
Lagunitas Creek tributaries (Bear Valley Creek, Devil's Gulch, and Cheda Creek)	GOGA (managed by PORE)
Pine Gulch Creek	PORE
West Union Creek and upper tributaries	GOGA

Table 2.2 Medium priority streams

Stream	Park
Strentzel Creek	JOMU
Franklin Creek	JOMU
Nyhan Creek	GOGA
Oakwood Creek	GOGA

Table 2.3 Low Priority Streams

Stream	Park
Additional Olema Creek tributaries (Quarry Gulch, Giacomini Gulch)	PORE
Webb Creek	GOGA
El Polin Spring (Creek)	PRES
Tennessee Hollow Creek	PRES
East Schooner Creek	PORE
Home Ranch Creek	PORE

Table 2.3 Low Priority Streams (continued)

Creamery Creek	PORE
A Ranch Perennial Creek	PORE
B Ranch Creek	PORE
C Ranch Creek	PORE
Kehoe Creek	PORE
Abbotts Creek	PORE
Muddy Hollow Creek	PORE

2.2.2 Site selection criteria, stratification, and randomization

Examples of stratification in water quality sampling sites include broad stream type (perennial, intermittent, ephemeral), watershed size, stream pattern (straight, meandering, braided) or other channel characteristics. Sampling can also be stratified by time (e.g., by varying the order of sampling sites). For the SFAN, since the streams are mostly small coastal streams with similar substrate and channel type, watershed size, and hydrologic conditions, a stream classification scheme was not used to decide on monitoring locations. No stratification was used to determine site locations.

Sites will be chosen based on the following criteria: 1) evidence or suspicion of contamination at a particular site (e.g., faulty septic systems, agricultural use, pet waste, outfall pipe), 2) human or aquatic health issue (e.g., there is a swimming area in the receiving water of a stream, 3) presence of a stream gauge or other permanent hydrologic monitoring equipment (linkage to freshwater dynamics vital sign), and 4) linkage to other aquatic vital signs (e.g., stream fish assemblages). Co-locating water quality sites with past or current macroinvertebrate or fish monitoring sites helps ensure data linkages. Ideally all sites within a given watershed are sampled on the same day (or even around the same time) or during the same storm event. Sites should represent inputs from all areas of the watershed (i.e., all major tributaries), capture the most downstream site within NPS property, and be permanent long-term sites (considering access). When choosing the number of sites within a watershed, we want to be as comprehensive as possible in representing the watershed while choosing a number of sites that is practical (considering laboratory and staff costs and logistics).

Control or reference sites will be used where applicable and pertinent to the monitoring questions. Where present, a particular tributary within a watershed may be suitable as a "reference reach". This stream would be most similar to other streams in the watershed in geology and be the most natural (unaltered geomorphology and land use).

Rather than simply using existing park or past monitoring stations, we first identified specific monitoring questions; existing or past sites were used to answer the questions if applicable. For example, there are six monitoring sites on Olema Creek that will be used. These are pre-established monitoring sites for the Regional Board's pathogen TMDL project. The selection of water quality sites and site IDs was based to a large extent on existing or past water quality monitoring sites. In some cases, the former site ID was also used so that past and future data can be compared. However, a more simplified, logical naming convention will be used in the final version of this protocol. A site ID history table explains when former sites were chosen as long-term monitoring sites. This table accompanies the site location and access table in Appendix E. Site locations are shown on maps in Appendix F.

2.3 Selection of parameters and protocols

The EPA Western Pilot Field Operations Manual for Wadeable Streams (Peck et al., 2001) and the National Field Manual (USGS, various dates) protocols will be followed for field methods. USGS protocol for stream discharge measurements will be followed (Rantz, 1982). The USDA Forest Service Redwood Sciences Laboratory protocol for turbidity and sediment sampling will be followed at the turbidity threshold sampling station on Olema Creek (U.S. Forest Service, 2002). Table 2.3 includes a broad overview of field methods. Laboratory methods for fecal indicator bacteria (FIB), nutrients, and total suspended solids (TSS) will follow “Standard Methods” (American Public Health Association, et al., 1998) or comparable EPA method. The SOPs will describe more protocol details not covered in this table. Summaries of the SOPs are provided in Section 3.0 of this protocol. The SOPs will rely heavily on local programs such as the State Water Resources Control Board’s Surface Water Ambient Monitoring Program (SWAMP) and the associated Quality Assurance Management Plan (Puckett, 2002).

Water quality varies over space and time in still waters. Rivers and streams are generally well mixed. Therefore, depth integrated sampling may not be needed except in the dry season where only pools may be present. The USGS National Field Manual (NFM) discusses depth-integrated sampling further. The study objectives need to be considered when determining sample collection procedures. For example, if analyte discharge measurements are desired, the USGS National Field Manual recommends that depth and width integrating sampling be conducted (Wilde et al., 1998).

Another reason that the USGS recommends depth-integrated sampling is that some forms of nutrients and bacteria are often associated with sediment particles. However, the San Francisco Bay Regional Water Quality Control Board does not use depth-integrated sampling for bacteria or nutrient TMDL monitoring. The Regional Board’s Surface Water Ambient Monitoring Program (SWAMP) does not collect depth-integrated samples for bacteria. Regardless, in many cases with the SFAN streams, there is not sufficient depth, except during storm events, to obtain a meaningful depth-integrated sample. In order to maintain consistency at all of the sites and throughout the sampling season, a “grab” or “hand-dipped’ sample will be obtained at a uniform depth (typically 4-8 inches).

Nitrate, ammonia, and total nitrogen will be monitored regularly for long-term trend detection and for short-term, localized toxic or eutrophic events. Ammonia transforms to different nitrogen species very quickly. In the winter there may be high levels of total ammonia, but low levels of the toxic, unionized ammonia. Also, even though a sample may have no unionized ammonia in one section of a stream there may be a toxic event in another section. Therefore, it is important to target certain areas of the watershed; this is achieved through a judgmental design.

EPA's recommended parameters for nutrient assessment are total phosphorous, total nitrogen, chlorophyll-a, and some measure of water clarity (e.g. turbidity for rivers and streams) (U.S. Environmental Protection Agency, 2000a). Nitrogen and phosphorous are the main causal agents of enrichment, while the two response variables, chlorophyll-a and water clarity are early indicators of system over-enrichment for most waters. However, it is generally agreed that Bay Area streams (i.e., freshwater systems) are nitrogen limiting, not phosphorus limiting. Therefore, any addition of nitrogen would impact aquatic growth and/or toxicity to organisms (Stafford and Horne, 2004).

Notes on Table 2.4:

1. Ideally each water body would have a continuous monitoring data set for at least one year; instrument (data sondes) collecting continuous data can be rotated between watersheds
2. Storm event sampling will be opportunistic but will be consistent for each site from year to year (i.e., an early/mid/late winter season storm will always be sampled).
3. In order to consider the potential of using field kits rather than laboratory analyses for nutrient parameters, field kits can be used in conjunction with laboratory sampling and the results can be compared.
4. (Ward et al., 1990) recommend reducing sampling frequency to once a quarter, unless looking for regulatory violations, to reduce serial correlation. However, there are often other variables of interest which change on a shorter time scale. If the same data is used for long-term trends and short-term exceedences measured values can be averaged over each quarter, so that there is just one value per quarter.
5. Maps of these water bodies are located in Appendix F.
6. Core parameters will be monitored continuously at sites on a rotating basis. Water level is monitored continously at sites where automatic recording stream gauges are located.
7. For streams that will be sampled during a storm event, the same general storm event will be monitored every year (i.e., first flush, mid, or late-season storm; 3rd storm event, etc.)

Key to Table 2.4

- Core parameters*: dissolved oxygen (D.O.), specific conductance, pH, and temperature
- Flow
- Water Level*
- FIB (fecal indicator bacteria): Fecal/Total Coliforms, *E. coli*,
- Nutrients: Total nitrogen, ammonia, nitrate/nitrite,
- Sediment: Turbidity and total suspended solids (TSS) or suspended sediment concentration

Table 2.4 Target streams, parameters, and protocols to be monitored

Stream	Park	Parameters	Frequency	Personnel	Protocols
Olema Creek	PORE	Core parameters, flow, FIB, nutrients, sediment, water level	Monthly; weekly for 5 weeks in summer and winter, continuous at one site; one storm event	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz , 1982 ; Peck et al., 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002); U.S. Forest Service, 2002.
Lagunitas Creek tributaries	PORE GOGA	Core parameters, flow, FIB, nutrients, sediment	Monthly, plus one storm event	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz , 1982 ; Peck et al., 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002); U.S. Forest Service, 2002.
Pine Gulch	PORE	Core parameters, flow, water level, FIB, nutrients	Monthly	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz, 1982 ; Peck et al., 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002)
Lower Redwood Creek	GOGA MUWO	Core parameters, flow, FIB, nutrients, sediment, water level	Monthly plus one storm event; one site continuous	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz, 1982 ; Peck et al., 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002)
Upper Redwood Creek	GOGA MUWO	Core parameters, flow, FIB, nutrients, sediment	Monthly plus one storm event	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz, 1982 ; Peck et al, 2001; APHA et al., 1992; State Water Resources Control Board (Puckett, 2002)
Rodeo Creek	GOGA	Core parameters, flow, FIB, nutrients, sediment	Monthly plus one storm event	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz, 1982 ; Peck et al., 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002)
Tennessee Creek (GOGA)	GOGA	Core parameters, flow, FIB, nutrients	Monthly plus one storm event	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz, 1982 ; Peck et al., 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002)
Nyhan Creek	GOGA	Core parameters, flow, FIB, nutrients	Monthly	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz , 1982 ; Peck et al, 2001, APHA et al., 1992; State Water Resources Control Board (Puckett, 2002)
Oakwood Creek	GOGA	Core parameters, flow, FIB, nutrients	Monthly	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz , 1982 ; Peck et al, 2001; APHA et al., 1992; State Water Resources Control Board (Puckett, 2002)

Table 2.4 Target streams, parameters, and protocols to be monitored

Stream	Park	Parameters	Frequency	Personnel	Protocols
West Union Creek	GOGA	Core parameters, flow, FIB, nutrients, sediment	Monthly during winter and spring	SFAN Water Quality Specialist	National Field Manual (USGS, various dates); Rantz , 1982 ; Peck et al, 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002); U.S. Forest Service, 2002.
Franklin Creek	JOMU	Core parameters, flow, water level, FIB, nutrients	Monthly	SFAN Water Quality Specialist; assistance from local volunteers	National Field Manual (USGS, various dates); Rantz, 1982 ; Peck et al, 2001, APHA et al., 1992; State Water Resources Control Board (Puckett 2002)
Strentzel Creek	JOMU	Core parameters, flow, sediment	Storm events	SFAN Water Quality Specialist; assistance from local volunteers	National Field Manual (USGS, various dates); Rantz, 1982 ; APHA et al., 1992; State Water Resources Control Board (Puckett 2002); U.S. Forest Service, 2002.
Chalone Creek	PINN	Core parameters, flow, FIB, nutrients, sediment	Monthly during winter and spring; one storm event	SFAN Water Quality Specialist with park staff assistance as available	National Field Manual (USGS, various dates); Rantz, 1982 ; Peck et al., 2001; APHA et al., 1992; State Water Resources Control Board (Puckett 2002)

The continuous probe will be moved from watershed to watershed on a rotating basis for Olema, Pine Gulch, Redwood, Tennessee Valley, Rodeo, Franklin, and Chalone Creeks)

2.3.1 Data Comparability

Significant measures will be taken not only to ensure that our data is comparable with other agencies, but to encourage universities, watershed councils and other volunteer groups conducting monitoring to document sufficient metadata. The network Water Quality Specialist coordinates with all entities involved in monitoring on parklands in order to optimize data sharing. Data comparability issues will be discussed and a metadata checklist will be distributed (see Ch. 4, Data Handling, Analysis and Reporting). The meeting will include representatives from the agencies/entities listed in section 1.2.3 above.

2.4 Sampling Frequency and Replication

There are many points to consider when determining when to collect a water sample and take field measurements. Ideally, dissolved oxygen would be measured in the early morning (just before dawn) when D.O. is expected to be lowest. This would capture the worst-case scenario and help determine whether the D.O. range meets the established criteria. The same holds true for pH – we want to capture the pH's that are outside the criteria range of 6.5-8.5. However, we don't yet know enough about the creeks to make decisions about when D.O. and pH levels would be most detrimental to aquatic life. These answers can be obtained over time. It is more realistic to answer these types of questions with continuous monitoring than with monthly monitoring.

Sites will be monitored at approximately the same time for each monthly sample event (i.e., sites will be monitored within a two hour window to the extent possible). The time of day that sampling occurs will be established during the first year of monitoring. The storm event (first, second third; early/mid/late season) will also be established during the first year of monitoring. Subsequent sampling years will mimic the initial monitoring year with regards to storm event and time of day.

The specific monitoring questions determine how sites are selected and the type and number of habitat(s) (riffle, run, pool) sampled. Some reasons to sample pools include that they are often the most contaminated, they allow for sampling in intermittent streams where riffles/runs are absent part of the year, and they are important fish habitat. Reasons to sample riffles include transport, flow, and load–related concerns (e.g., sediment transport, fecal coliform load for TMDL monitoring). Information from riffles can also be used in conjunction with stream macroinvertebrate data.

The primary sampling objective is to sample and take stream measurements in the centroid of flow wherever possible (see SOPs #5-8). For intermittent streams with isolated pools in the summer/fall it is also important to take samples and measurements in these pools since they are areas of fish refuge. Toxic ammonia, low D.O., and high temperatures are potential threats to aquatic life. For intermittent streams, core parameters will be sampled in pools and riffles for all intermittent streams in order allow comparisons and determinations of annual and seasonal variability. Tables 2.5a and 2.5b provide a summary of habitat sampling differences for perennial and intermittent streams. Following this sampling regime will allow SFAN to answer specific monitoring questions listed in Appendix D. SFAN will follow the rotating watershed schedule listed in Table. 2.6.

Table 2.5a Habitat Sampling in Perennial Streams

Parameter	Pool	Season	Riffle/Run	Season
Core parameters			X	All
Bacteria			X	All
Nutrients			X	All
Sediment			X	Winter/spring

Table 2.5 b Habitat Sampling in Intermittent Streams*

Parameter	Pool	Season	Riffle/Run	Season**
Core parameters	X	All	X	Winter/spring
Bacteria	X	Summer/fall	X	Winter/spring
Nutrients	X	Summer/fall	X	Winter/spring
Sediment			X	Winter/spring

* Some site on intermittent streams may have perennial flow
**There may be years when there is flowing water well into summer; in this case sample based on flow not season.

Table 2.6 General Water Quality Monitoring Schedule

Stream	Park Unit	FY06	FY07	FY08	FY09
Olema Creek	PORE	M, S, W	M, S, W	M,S, W	M,S,W
Lagunitas Creek	PORE/GOGA			M	M
Pine Gulch	PORE	M	M		
Lower Redwood Creek	GOGA/MUWO			M ,S	M, S
Upper Redwood Creek	GOGA/MUWO			M	M
Rodeo Creek	GOGA	M, S	M, S		
Tennessee Creek	GOGA	M, S	M, S		
Nyhan Creek	GOGA	M, S	M, S		
Oakwood Creek	GOGA	M, S	M, S		
West Union Creek	GOGA			M	M
Franklin Creek	JOMU	M	M		
Strentzel Creek	JOMU	S	S		
Chalone Creek	PINN	M, S	M, S		

M monthly monitoring (Winter and Spring only for Chalone Creek and West Union Creek)
S monitoring during at least one storm event
W weekly monitoring for five weeks in winter and summer

Opportunities for phasing-in additional water bodies (e.g., Presidio streams) or eliminating the rotating basin approach will continue to be considered. Due to the current pathogen TMDL program monitoring on Olema Creek, it will continue to be monitored annually for the forseeable future. Ideally, Lagunitas Creek tributaries would also be monitored annually since this stream is an impaired water body. However, nutrient and sediment TMDL monitoring programs are not yet in place for this creek (expected by 2008). Lower Redwood Creek is currently being monitored through 2006 as part of the Big Lagoon Restoration project. This is a short-term monitoring program designed by a consultant and modified by GOGA (Stillwater Sciences, 2004) and will end before FY08; hence, it is recommended that I&M assume monitoring for the entire watershed (Upper and Lower Redwood Creek) at that time. Also, where trend monitoring is a priority, sites will not be rotated but will be monitored every year. Other options are to conduct monthly monitoring of core parameters on all streams so that if there are any major problems, parks can be alerted. Monitoring for nutrient and bacteria parameters could then be conducted only quarterly, or monthly on a rotating schedule.

3.0 FIELD AND LABORATORY METHODS

Standard operating procedures (SOP) will cover field season preparations and equipment, sequence of events in the field, details of taking measurements (including example field forms), post-collection processing of samples (e.g., lab analysis), end-of-season procedures, quality assurance/quality control (QA/QC), and all other details of water quality monitoring. The bulk of information related to field methods is included in SOP 1 and SOP 5. Most of the laboratory related details are included in SOP 7, SOP 8, and SOP 9. SOP 4 covers the majority of details related to QA/QC.

3.1 Standard Operating Procedures

All aspects related to field and laboratory methods are included in Standard Operating Procedures. Methods follow existing national programs (EPA and USGS). Quality assurance and quality control methods follow California Water Resources Control Board EPA-approved guidelines for Quality Assurance Project Plans. Details of field methods and implementation are outlined in the SOP documents including:

SOP 1: Revising the Protocol
SOP 2: Personnel Training and Safety
SOP 3: Equipment and Field Preparations
SOP 4: QAPP (QA/QC SOP)
SOP 5: Field Methods For Measurement of Core Parameters
SOP 6: Field Methods For Sampling Bacteria
SOP 7: Field Methods For Sampling Nutrients
SOP 8: Field and Laboratory Methods For Sediment
SOP 9: Field Methods For Flow (Stream Discharge)
SOP 10: Data Analysis
SOP 11: Data Reporting
SOP 12: Site Selection and Documentation

<u>SOP 1: Revising the Protocol</u>
This SOP refers to revisions to be made after the monitoring plan has been implemented in October 2005. Data analysis after the first year or two of monitoring will help determine whether the monitoring data collected adequately answers the stated questions and meets objectives. Revising the protocol to thoroughly answer the monitoring questions will be a top priority. Practical issues to be considered include: sampling frequencies, site location, logistics of transporting samples to laboratory, and effectiveness of the protocol during storm events. It is essential to make these critical changes earlier in the implementation of the monitoring plan to ensure long-term effectiveness of the protocol. Therefore, it is expected that the majority of major changes (i.e., those having the most effect on sampling design and statistical analysis) to the protocol would be made in the first few years. Any changes to the protocol or SOPs will be documented in a revision history log. In addition, the SOP emphasizes the importance of overlap in equipment, methods, and staff when changes occur.

SOP 2: Personnel Training and Safety
At least two network or park individuals will be trained initially. This will help ensure continuity should one person leave a position or otherwise not be available for a particular sampling event. In addition, it will be mandatory that two field staff be present for sampling during storm events (see safety SOP) and it is recommended at other times as well. Staff will be trained through review of written guidance plus a series of consecutive sampling events. The overall project purpose, protocols, equipment manuals, and field maps will be reviewed before commencing fieldwork. The first sampling event (or first group of sites in an event) will be used to demonstrate the sampling process including QA/QC. The second sampling events or group of sites will give the trainees an opportunity to sample with guidance. The trainer (water quality specialist, hydrologist, or hydrologic technician) will periodically accompany the recently trained individuals to ensure that the protocol continues to be followed and to address any questions.

The safety SOP ensures that safety will be a priority in the short and long-term. The SOP will stress the importance of radio use, team communication (e.g., sign-out sheet or buddy system) and sound judgement. The SOP will also individually address potential safety hazards by focusing on an existing Job Hazard Analysis created for the aquatics program at GOGA. In addition, USGS standard safety protocols will be incorporated (Lane and Fay, 1997).

Sampling during storm events is of particular concern in Mediterranean climates. Most, if not all, of the streams in the SFAN have a rapid response time (hydrograph) with stage rising rapidly during a storm event. For example, individuals taking flow measurements in Chalone Creek (PINN) have had to end flow measurements since the stage rose to an unsafe level during the short time that the velocity measurements were being taken.

Other potential hazards to be considered at all parks include flowing logs and other debris, quicksand (particularly at PINN), falling trees, drowning, falling, back injuries from lifting/bending/falling, poison oak and stinging nettle, and (though rare) large predators such as mountain lions. Though some of these hazards are rare, it is important to be aware of all of them. A thorough list of hazards is particularly useful for staff who may not be familiar with the local weather and climate, topography, flora, or fauna.

SOP 3: Equipment and Field Preparations
This SOP will follow guidelines provided by the manufactures (e.g., Oakton, YSI, Inc., Marsh-McBirney, Rickly Hydrologic) for equipment operation and maintenance as well as common sense. This includes calibration methods and frequency, cleaning, changing pH electrodes, D.O. membranes, etc. In addition, a field equipment checklist is included in the protocol. This lists all required and optional equipment to be carried with the field crew (or in the field vehicle) and all times. The checklist is provided for review before leaving the base park/office for each sampling event. End-of-season procedures will also be covered here.

SOP 4: Overall Quality Assurance Project Plan (QAPP)
Following NPS guidance from (Irwin, 2004), the QAPP or QC SOP will include 1) QC objectives for measurement certainty (detection limits such as MDL (method detection limit) and PQL (practical quantitative limit), 2)QC objectives for measurement precision, 3) QC objectives for measurement systematic error (bias as percent recovery), 4) QC objectives for data

completeness (including adequacy of planned sample sizes and statistical power), and 5) QC objectives for blank controls for lab measurements. Individual SOPs for parameters will also include discussion related to data comparability and selection of laboratories and protocols. SOPs will be highly detailed (e.g., indicating how many duplicate samples will be collected for QC) so that other agencies can determine whether they can utilize SFAN data in conjunction with their own data). The California Department of Water Resources "Guidelines for Preparing Quality Assurance Project Plans" (1998) will be followed.

SOP 5: Field Methods for Measurement of Core Parameters

This SOP will primarily focus on the use of multiparameter probes for measuring basic water chemistry parameters. Specifically, the YSI 85 will be used for determining dissolved oxygen concentration and percent saturation, specific conductance, salinity, and temperature. Handheld, waterproof pH meters will be used in conjunction with the YSI 85. The SOP will also discuss the use of continuous monitors for temperature, conductivity, pH, and dissolved oxygen. Details of this field SOP will focus on the actual in-situ measurement (e.g., location of probe within sample site, location of probe in water column, proximity to streambank, differences in measurement techniques in pools versus riffles, etc.) Equipment use and preparations prior to fieldwork are discussed in the Equipment Calibration and Handling SOP.

SOP 6 & 7: Field Methods for Sampling Bacteria and Nutrients

Details of this field SOP will focus on the actual sampling (e.g., sterile technique to avoid contaminating a sample, location of sample in the water column, proximity to streambank). Details of sample bottle labeling, storage, and transport to laboratories (including chain of custody protocols) will also be discussed. Laboratory methods will also be discussed.

SOP 8: Field and Laboratory Methods for Sediment

This SOP discusses all aspects of monitoring sediment (i.e., total suspended solids and turbidity). This includes preparation of sample bottles, how to collect a sample in the field, laboratory analysis using the oven-dry weight method for TSS, and use of a Hach 2100 turbidimeter. Depth integrated sampling and use of in-site turbidity sensors will also be discussed as well as integration of sediment monitoring with other vital signs monitoring (e.g., freshwater dynamics/stream hydrology). Operation and maintenance of the network's turbidity thresholds sampling unit is also introduced.

SOP 9: Field Methods for Flow Measurements

Flow will be measured quantitatively at stream gauges (pressure transducer water level monitors such as Global or Druck, Inc.) using the USGS method for measurement of stream discharge (Rantz, 1982). Quantitative streamflow will also be assessed at sites related to TMDL projects in order to calculate loads to a 303d listed water. Where time or storm conditions do not permit safely measuring flows, then a quanitative estimate will be provided. In addition, regardless of whether a flow measurement can be taken, a qualitative description of flow will also be provided. This is often referred to as a flow severity value and has several categories. These categories include: no flow (pools present), dry, low, medium, high, flood. Other methods and instructions on when to use a particular method will be discussed further in the SOP.

SOP 10: Data Analysis
An overview of data analysis is covered in Ch. 4. However, more details will be provided in the SOP that will cover summary statistics, comparing data to water quality criteria, and QQ/QC measures such as calculating duplicate precision. The data analysis SOP will follow the Greater Yellowstone Network's (GRYN) SOP #9 for Data Analysis (O'Ney, 2005).

SOP11: Data Reporting
This SOP provides details on reporting intervals, content, and format. It closely follows other networks data reporting SOPs as well as the SFAN Data Management Plan.

SOP 12: Site Selection and Documentation
This SOP will discuss various permits or contacts required before commencing fieldwork. Access issues will be covered such as obtaining keys or combinations for locks and being sensitive towards landowner concerns. Other topics to be discussed include randomization do determine a sampling location within a sampling site. Site documentation is also covered including photographic documentation (periphyton, gravel bars, riparian cover) and site naming conventions

Data Collection and Management
There is no established data collection SOP for Freshwater Quality. However, the Network's overall Data Management Plan (Press, 2005) should be consulted. Some of the suggested methods for data collection include: 1) using an established field data sheet instead of a field notebook, 2) using a handheld computer to enter data, 3) using a handheld tape recorder and later transcribing the data, 4) keeping a log of any decisions made, 5) ensure proper training for field crews. The third suggestion can be useful if there is only one person collecting field measurements, particularly flow measurements. The use of automatic dataloggers is also recommended and this is incorporated into this protocol as well as the SFAN freshwater dynamics protocol.

3.2 Field and Laboratory Methods Overview

Field and laboratory methods are covered in detail in the QAPP and SOPs. Field and lab documentation, sample handling, logistics, and measurement quality objectives for field and laboratory parameters are covered in the QAPP. Only labs approved for the parameters of interest by the State and the National Environmental Laboratory Accreditation Program will be utilized.

Additional research will be conducted to obtain information from several labs between the time the protocol final draft is complete and FY06 funds are available for a lab contract. Laboratory detection limits must meet the specific guidelines outlined in the QAPP.   Any change of labs should be thoroughly documented. Any change in methods or personnel should also be documented and overlap should be provided/conducted when possible

4.0 DATA HANDLING, ANALYSIS AND REPORTING

Roles and responsibilities for data managers, project managers, and the Network Coordinator in relation to data management are outlined in the SFAN Data Management Plan (Press, 2005). The Data Management Plan also provides guidance on dealing with legacy data and non-programmatic data from internal (NPS) and external sources. The SFAN Water Quality Specialist will coordinate with internal and external monitoring programs regarding acquisition of legacy data and metadata.

4.1 Metadata Procedures

Metadata reporting is accomplished through the metadata template located on the main switchboard of the NPSTORET database. The metadata template consists of nine categories including:

1) Collection Procedures
2) Gear Configurations
3) Preserve/Transport
4) Analytical Procedures
5) Lab Sample Prepration
6) Characteristics
7) Laboratory Information
8) Staff and Roles
9) Citations

A metadata checklist (D. Tucker, personal communication, 5 December 2004) will be used and presented to all individuals conducting water quality data collection. The checklist is included in Appendix G of this document. Field data sheets will contain much of the metadata and the checklist will help ensure that additional metadata is documented and tracked by field and office personnel. Metadata will be checked at least twice by the SFAN Water Quality Specialist before submission of the yearly NPSTORET Database to WRD.

4.2 Overview of Database Design

The SFAN will be utilizing the NPSTORET database produced by WRD. This database is a modification of EPA's STORET (Storage and Retrieval) database. The long-term location of the master database is on the GOGA network (X:\Individual VitalSigns\Water Quality\NPSTORET). The SFAN Water Quality Specialist will be responsible for managing the master database. Satellite copies of the SFAN NPSTORET database will be located on servers at PINN and PORE.

Satellite databases will be created at the beginning of each water year. The water year is generally from October to September. Individuals entering data into satellite copies are responsible for verifying data. They should also create back-up copies of the database on a CD or zip drive or on a different server or computer. The satellite databases will be brought into the master database at the end of each water year.

Data storage templates for NPSTORET include projects, stations, metadata, and results. All data for this program will be entered under the project name: SFAN Water Quality Monitoring Program. NPSTORET will run under Microsoft Access 2002 or higher.

The project template includes fields for project identification, contacts, and study area description, sampling design summary, Quality Assurance Project Plan (QAPP) summary, measurement quality objectives (MQO), citations, project characteristics, and personnel. The metadata checklist includes a synopsis of all the fields within the station template. The station template provides a location to store station photographs.

Notes to include in the SFAN version of NPSTORET include: 1) upstream and surrounding land usage 2) site observations even if normal, 3) indicated whether the station is control or not, 4) indicate whether the stream is ephemeral, intermittent, or perennial, and 5) indicate the type of water body, e.g., stream mainstem, tributary, pond, lagoon, lake.

There is a SIM Export buttom in the NPSTORET that creates a data file that is easily transferable to WRD for inclusion in the overall version of NPSTORET and ultimately to EPA's STORET in Washington, D.C. Also, NPSTORET will export data in Microsoft Access, Microsoft Excel, or comma or space delimited Text format for further data analyses.

In addition to managing data in NPSTORET, PORE data will also be provided to the Tomales Bay Watershed Council (TBWC) database. A unique feature of this database is that is has a hierarchical structure that denotes the location of every water body in relation to every other water body. The SFAN and PORE staff have been coordinating with the TBWC over the past few years (including providing feedback on their database) and this is expected to continue in the future.

4.3 Data entry, verification and editing

4.3.1 Data Entry

Data will be reviewed upon receipt from a laboratory and during and immediately after field measurements (this is also true of data from data loggers such as turbidity sensor or pressure transducer data). This helps identify potential equipment problems and/or presence of pollutants. Full data analysis is not necessary until a complete set of data is gathered (annual), but it is essential to preview data as it is gathered. This includes comparing site data to expected results. For example, a pH of 12 is outside the established range for the SFAN sites and the data reviewer would need to determine the source of error. Similarly, the NPSTORET database will have functions that can detect errant values that are entered. For example, a pH of 15 is not possible since it is on a scale of 1-14, so the program would not allow "15" to be entered as a pH measurement. The individual reviewing the data should have a working knowledge of what would be expected for that stream or watershed in different seasons, etc.

Data will be reviewed within a week after each sampling event for inconsistencies related to field personnel, how well SOPs are followed and how timing and logistics of sample collection and transport to laboratories may be affecting sample data. Also, at this time, any field notes regarding broken equipment or other needs (calibration, batteries, replacement) can be addressed in time for the next sampling event. The SFAN data managers will work with the SFAN water quality specialist to ensure that data is well-understood and entered into the proper fields in NPSTORET. This coordination will also help ensure that metadata is complete and accurate. Data will be entered into the SFAN NPSTORET database no less than once a month to ensure adequate interpretation of field notes and receipt of proper laboratory QA/QC information. Entering data soon after collection and receipt of data from the laboratory ensures that labs are providing the needed data (including MDL, PQL) and handling samples properly.

4.3.2 Data Verification

The accuracy of digitized records should be verified with field and laboratory data sheets. Once data is entered into the database, a different individual verifies the datasheet information against the database. Field staff will verify each of the field sheets that are entered into the database. As a QA/QC measure, the project manager will verify approximately 10% of the data entered. See the QAPP for additional details.

4.3.4 Data Validation

Data validation is the final step in assuring the accuracy of data transfer from raw to digital form. Questionable data are identified, reviewed, and corrected if necessary. Automatic validation that checks the data as it is entered is built into NPSTORET and will be modified, if necessary, for the SFAN version of NPSTORET. These automatic validations are programming elements that "censor" the data based on known ranges. Therefore the data manager would not be allowed to enter data that is invalid such as 16 for pH or a date in the future. Through this process, outliers are identified. Examples of common errors are missed decimal places, numerical data placed in the wrong field (for example, the database shows a pH of 12 when 12 is actually the water temperature). Outliers can be identified through simply graphing all observations for a given station and parameter or graphing all station data together if there is only low to medium variability.

4.4 Routine data summaries and statistical analyses to detect change

This section is intended to provide an overview of statistical analyses appropriate for water quality data. It address particular features of water quality data sets that are unique and discusses methods of dealing with these features. More detailed and specific data analysis techniques are included in SOP#10 – Data Analysis. This SOP also covers details of data representation including tabular and graphical data.

4.4.1 Characteristics of Water Quality Data

Most traditional statistical methods are based on the assumption that the data being analyzed have originated from a population (of measurements) with a normal (symmetric) distribution. Classical statistics makes other assumptions including uncorrelated data and constant variance for populations being compared (Gilbert, 1987). However, water quality data typically has a non-normal distribution (due to a lower bound of zero, the presence of outliers, and positive skewness). Seasonality and autocorrelation are also common as well as covariance with other variables such as discharge (Helsel and Hirsch, 2002). All these factors are important in deciding types of analysis to use since the ability to detect trends is dependent upon the variability of the data, as well as the responsiveness of the indicators (parameters), and sample size (Irwin, 2004).

Water quality data is usually highly variable, both temporally and spatially. Temporal variability is caused by autocorrelation (serial correlation) and by seasonality. Ward et al. (1990), recommend reducing sampling frequency to once a quarter, unless looking for regulatory violations, to reduce serial correlation. However, there are often other variables of interest which change on a shorter time scale than three months. For example, if the same data is used for long-term trends and short-term exceedences, measured values can be averaged over each quarter, to provide just one value per quarter. This method could also be useful in analyzing large data sets with varying sampling frequencies (common with past water quality data). Seasonal variation can often be explained by variation in discharge. However, seasonality sometimes remains in the data set even after accounting for flow effects. In these cases, seasonal variation can be reduced by analyzing data grouped by season (Hirsch et al., 1982). See section 4.6 for more on seasonality and data analysis.

4.4.2 Preparing the Raw Data Set for Analysis

4.4.2.1 Censored and missing data

In addition to the above characteristics, water quality data is commonly "censored" or reported as less than or greater than the detection limit (this has been common for ammonia and nitrate data within the SFAN as well as fecal coliform data). This data is considered outside the range of quantitation. In other words, it cannot be accurately quantified and represented as a numerical value). Data outside the range of quantitation will not be statistically analyzed. More information on dealing with censored data is included in the SOP#10 – Data Analysis. For more information on the range of quantitation, detection limits, etc. refer to SOP#4 – Quality Assurance Project Plan.

Uncensored data is particularly an issue with FIB data. Knowledge of the water quality patterns, with relation to location and storm event, is required in order to determine if a bacteria sample should be diluted and to what magnitude. Having an educated guess of what the dilution should be for a given sample is essential to limiting the number of results that are censored.

4.4.2.2 Replicates

Replicates from the raw data record should be averaged together and the single mean value used in their place for analysis, or else the median value should be used. The standard deviation or range of the replicates provides an estimate of the variability in the measurement technique (Stafford and Horne, 2004).

4.4.2.3 Data transformations

Data transformations can be utilized including logarithmic transformations and adjusting data for flow. Logarithmic transformations will be used particularly with FIB data since transforming allows for a more simple data analysis and graphical display of data with a range that often spans over several orders of magnitude. In addition geometric means, required for regulatory monitoring of FIB, are calculated after log transformations (see SOP #10).

Logarithmic and flow transformations can make the data more "normal" in distribution and increase the possibility of using parametric statistics which are slightly more powerful for determining statistical differences. An advantage of using the medians and interquartile ranges to describe central tendencies is that they remain the same even when the data is transformed whereas the mean and standard deviation change (Helsel and Hirsch, 2002).

4.4.3 Data Analysis: Techniques & Issues

Non-parametric statistical tests are more appropriate for non-normal data and are used to describe distributions in water quality data. The median and interquartile range (IQR) (middle 50% of data points) will used instead in addition to the mean and standard deviation typically used for normally distributed data (Hirsch et al., 1991). The median is particularly useful for water quality data since it is less sensitive to outliers than the mean (Zar, 1999).

Confidence intervals (95%) will be used to bound uncertainties in means and medians (Irwin, 2004). Summary statistics and correlation techniques will be used to quantify relationships between water quality parameters. To limit seasonal variability, statistical tests will be conducted for each of the different seasons.

Trend analyses will also be conducted following techniques discussed in "Statistical Methods in Water Resources" (Helsel and Hirsch, 2002). As WRD suggests (Irwin, 2004), traditional hypothesis tests will not be used. Modified hypothesis testing may be used for trend detection. Methods for long-term trend analysis (e.g., every 5 or 10 years) are discussed further in SOP#10.

Table 4.1 describes the broad types of data analysis for each monitoring question. For each monitoring question, individual station data will be summarized seasonally and annually. Data from all stations within each watershed will also be summarized seasonally and annually. Discrete and continuous data will be analyzed separately. However, data from the same days will be compared for quality control and to obtain a relationship between the datalogger readings and instantaneous monthly/weekly data. All data will be compared with water quality standards by graphing the data along with a "criteria line" on the graph that clearly shows which measurements fall above or below the standards. Within each watershed, data from stations upstream and downstream of a suspected pollution source or tributary will be compared. Summary tables, histographs, and box and whisker plots will be used to show median and interquartile ranges (non-parametric), mean and standard deviation (parametric), and 95% confidence intervals for means and medians.

Table 4.1 Sampling Designs and Data Analysis Based on Monitoring Questions

Monitoring Question	Overall Sampling Design & Analysis
What are the existing chemical and biological ranges in water quality within the freshwater systems of the SFAN?	Analyze annual, seasonal, and daily data for each station and each group of stations in a stream or watershed.
What are long-term trends in water quality in the SFAN water bodies?	Analyze data from sites in the upper, middle, and lower reaches if possible, or at the stream source and mouth. Analyze annual and seasonal data for each station and for each group of stations in a stream or watershed.
Is the water quality of the SFAN water bodies in compliance with beneficial uses?	Focus on sites known or suspected to be impaired; analyze data for each site for each group of stations (collectively) in a stream. Compare reference reach range with impacted reach range.
What are the pollution sources within the watersheds?	Compare data from individual sites from one sampling event to another; also compare data from multiple sites within a stream. Analyze annual and seasonal data for each station and for each group of stations in a stream or watershed. Compare variability in reference reaches with variability in impaired reaches.
*Are specific management actions reducing pollution loads?	Compare data from individual sites from one sampling event to another; also compare data from multiple sites within a stream. Analyze annual and seasonal data for each station and for each group of stations in a stream or watershed.

*Documenting effectiveness generally requires higher frequency sampling over more than two years (Dave Lewis, personal communication, 28 July 2005). Therefore, this may be a situation where the I&M program notifies parks of pollution sources so that parks can implement management practices and potentially augment existing I&M monitoring.

4.5 Reporting schedule and format

The SFAN Data Management Team will ensure that data from the network's version of NPSTORET is provided to WRD on an annual basis. An additional requirement for WRD is to provide a report that includes a paragraph summary for each parameter plus summary graphs of each site. In addition, summary paragraphs will be provided for each watershed including any proposed management activities related to water quality improvements. Recommendations for revising the protocol (changing monitoring intervals and timing, moving/adding sites, etc.) will also be proposed. These annual reports will also be provided to the SFAN parks.

Several types of reports are discussed in the SFAN Data Management Plan; at least three of these will be used by the freshwater quality monitoring program. These reports and their purposes our listed below (*from* Press, 2005):

Annual Report:
-Archive old data and document monitoring activities
-Describe current condition of the resources
-Document changes in the monitoring protocol
-Increase communication within the park and network

Analysis and Synthesis Report (3-5 years)
-Determine patterns and trends
-Discover correlations among resources being monitored
-Analyze data to determine the level of change that can be detected using the existing sampling scheme
-Provide context, interpret data for the park within a multi-park, regional, or national context
-Recommend changes to management practices

Program and Protocol Reviews
-Periodic formal reviews of operations and results
-Review of protocol design and product to determine if changes are needed
-Part of the quality assurance – peer review process
A comprehensive data analysis and synthesis will be written every few years in addition to more simplified, general annual summaries. Having this extra time allows for more thorough data analysis and review of protocols and may give greater opportunity for adaptive management. More details on data reporting are included in the Data Reporting SOP (#11).

4.6 Data archiving procedures

Electronic data archiving includes long-term storage and access through the network server. The NPSTORET database and all reports will be available electronically through the GOGA main server where all I&M files are stored. In addition original data sheets and copies of reports will be stored in GOGA archives with hard copies potentially available in the GOGA Resource Management building where many I&M program staff are located. Once data has been validated/verified and the appropriate QA/QC procedures conducted (see the QAPP), the SFAN Water Quality Specialist will notify the Network Data Manager that the dataset is ready to be archived. All archived data will be stored in the secure Archive folder on the network server. The suggested directory structure for archived project folders is in the SFAN Data Management Plan.

5. 0 PERSONNEL REQUIREMENTS AND TRAINING

5.1 Roles and responsibilities

The Water Quality Monitoring Program Leader will be a Network Water Quality Specialist (GS-6/7). This individual will be responsible for conducting fieldwork and all QA/QC measures, data management, data analysis, and reporting and will be supervised by the Network Coordinator. The Network Data Manager, Park Hydrologists, and other aquatic resources staff at the park and regional level will provide assistance and guidance when necessary.

The Network Water Quality Specialist will also coordinate all contract management activities related to the water quality monitoring program. The individual will coordinate with resource management staff at the parks to ensure monitoring goals are being met, to keep parks informed of monitoring activities, and to pursue funding opportunities. Partnerships and coordination with other agencies/individuals will include the Tomales Bay Watershed Council, Marin County Environmental Health Services, and the Regional Water Quality Control Board.

The Network Water Quality Specialist would work closely with other SFAN staff to integrate weather and stream hydrology (freshwater dynamics) monitoring components with water quality monitoring thereby limiting travel, improving efficiency, and optimizing safety. Park and network staff will work together when possible, particularly during storm events. This is a safety measure as well as a QA/QC measure.

5.2 Qualifications and training

See Section A8 of the QAAP for staff training/qualifications. Also, SOP 2 (training) and SOP 3 (safety) will include other details regarding staff requirements.

6.0 OPERATIONAL REQUIREMENTS

6.1 Annual workload and field schedule

A general monitoring schedule for the SFAN water bodies was presented previously in Table 2.2. Time commitments for the water quality specialist will be approximately 50% for field work and 50% for data management, analysis, and reporting. The field work load will be heavier in the winter. Since some parks or streams will not be monitored in the dry season (summer/fall), this is when the majority of the data analysis and reporting will occur. It is anticipated that data entry/management will be on-going in conjunction with the field work. Where possible, efforts will be made to obtain additional help for data entry. The project lead (Water Quality Specialist) would then be more available for data validation and QA/QC measures. Also, where possible, the other park and network staff will assist with water quality monitoring in order to improve efficiency and safety.

6. 2 Personnel Organization and Program Oversight

The GS-6/7 Water Quality Specialist will be responsible for implementing the SFAN Freshwater Quality Protocol. The position will be term subject-to-furlough for the immediate future. A permanent position may be considered in the future dependent on funding.

The Network Water Quality Specialist will be directly supervised by the PORE Hydrologist. Duty station will be at the PORE headquarters. There is currently a dedicated office space for the individual at the PORE. Office space will also be provided at GOGA (Fort Cronkhite) in the same location as the Network Coordinator, Lead Data Manager, and Vegetation Ecologist. The Network Coordinator will provide programmatic oversight for data management, analysis, and reporting. In addition, the Network Aquatic Professionals Group will meet quarterly in order to maintain communication and coordination among the parks and between the parks and I&M staff. Additional individuals will assist with field work and data validation/verification tasks. These may be network technicians or park staff. Also, where possible the SFAN Water Quality Specialist and Network Hydrologic Technician will coordinate field activities and data management tasks where possible.

<u>The SFAN Aquatic Professionals Group will consist of:</u>
GOGA Hydrologist
GOGA Aquatic Ecologist
Network I&M Coordinator (will represent JOMU and EUON as well as overall network)
Network Data manager
*Network Hydrologic/Weather Technician or Intern
*Network Water Quality Specialist
PINN Resource Manager
PORE Hydrologist
PWR Aquatic Ecologist (pending Technical Assistance request through WRD)

*These individuals may not participate in all meetings, particularly those related to management issues such as budget and personnel

Tasks for the SFAN Aquatic Professionals Group

- Conduct quarterly meetings to accomplish the following tasks:
- Provide input for the Stream T&E and Fish Assemblages, Freshwater Quality, Freshwater Dynamics, and Weather Monitoring programs
- Communicate network and park needs and work together to prioritize and resolve issues
- Make decisions regarding personnel hiring and program implementation
- Provide a forum to discuss monitoring results
- Review and approve workplans for network staff including the Water Quality Specialist and Hydrologic Technician
- Review technical reports (e.g., annual reports to WRD) and provide technical and programmatic oversight
- Assist Network Water Quality Specialist in recruiting field assistance among park and network staff
- Assist with coordination of aquatics group meetings
- Establish a MOU with state agencies conducting monitoring programs
- Participate in I&M Technical Steering Committee Meetings as a water resources representative (as needed)

Tasks for the SFAN Water Quality Specialist:

- Be well-versed in all aspects of the SFAN Freshwater Quality Protocol and conduct protocol revisions
- Coordinate logistics for field work and laboratory sample drop-off
- Coordinate field assistance for protocol implementation and provide training to field assistants
- Calibrate and maintain equipment in good working order and keep maintenance records
- Collect field data and implement field QA/QC measures
- Coordinate with laboratories regarding field sampling schedules and measurement quality objectives (QA/QC)
- Coordinate data entry, verification, and validation and consult with network data managers
- Perform statistical analyses on data; present and interpret results in technical reports
- Coordinate with PORE Hydrologist regarding staff and training needs, data analysis and data interpretation
- Coordinate with PORE Hydrologist regarding budget, vehicle, and equipment needs
- Assist with coordination of Aquatics Group Meetings
- Coordinate with USGS and WRD on Level 1 Water Quality Inventory
- Provide regular updates to the aquatics group including a summary of data and related activities

Broad tasks for PORE Hydrologist

- Provide technical assistance and supervision for the SFAN Water Quality Specialist
- Develop and conduct performance review (to be reviewed by aquatic professionals group)
- Manage WRD Water Quality Monitoring Program budget
- Manage laboratory contracts for the SFAN Freshwater Quality Monitoring program
- Assist in coordination of Aquatic Professionals Group Meetings
- Provide or coordinate training for the SFAN Water Quality Specialist

- ♦ Conduct annual QA/QC field checks
- ♦ Participate in I&M Technical Steering Committee Meetings as a water resources representative

Broad tasks for Network Coordinator
- ♦ Participate in Aquatic Professionals Group meetings
- ♦ Coordinate guidance on data management, data analysis and reporting
- ♦ Provide information related to I&M program requirements including reporting requirements and deadlines
- ♦ Review technical reports and provide programmatic oversight

Tasks for Network Data Manager
- ♦ Provide assistance to the Network Water Quality Specialist regarding data management, archiving, reporting
- ♦ Assist with GIS needs
- ♦ Assist in coordinating with WRD regarding the NPSTORET database
- ♦ Assist with compilation of metadata for past and current monitoring programs; develop a scope of work for dealing with legacy water quality data throughout the network

6.3 Facility and equipment needs

An inventory of all park and network equipment is included in SOP#3 – Equipment and Field Preparations. The SFAN Water Quality Monitoring Program has a dedicated aYSI 85, pH meters, and a flow meter. Primary equipment costs will be related to purchase of continuous dataloggers for determining daily variability on water quality parameters. Another significant cost would be calibration of flow meters. Other anticipated costs include repair or replacement of old meters and purchasing supplies such as calibration kits, buffer solutions, batteries, gloves, etc. Equipment lists specific to each monitoring parameter are included in the SOPs.

Total suspended solids (TSS) analysis can be conducted "in-house" in the wet lab located at GOGA (Marin Headlands). The lab contains a balance, sink, vacuum, and drying oven used in TSS analyses. See SOP#8 – Field and Laboratory Methods for Sediment.

6.4 Startup costs and budget considerations

Table 6.1 Cost of laboratory analysis by parameter

Analyte	**Method Code**	**Method Name**	***Cost per sample**
Fecal/Total coliform	SM 9221B	/Multiple Tube Technique (MPN)	$30.00
E. coli/Total coliform	SM 9223B	Quantitray (MPN)	$20.00
Total Nitrogen	SM 4500	Persulfate Method (oxidation to nitrate)	$50.00
Ammonia	SM 4500F	Phenate Method (spectrophotometric)	$25.00
Nitrate and Nitrite	SM 4500	Colorimetric or cadmium reduction	$40.00
Total suspended solids	SM 2540D	gravimetric	in-house lab
Suspended Sediment	SM 2540D	gravimetric	$20.00

*Approximate cost; prices will vary by laboratory

6.2 Cost of laboratory analysis by stream for FY06-07 (update)

Creek	All Sites	Proposed Sites Only
Chalone*	$6,140	$3,895
Olema*	$13,295	$11,550
Pine Gulch	$5,025	$5,025
Rodeo*	$4,890	$3,260
Tennessee*	$2,550	$1,745
Nyhan (A)	$1,285	
Oakwood (A)	$805	
Franklin	$1,650	$1,650
Strentzel (A)	$1,350	
	$36,990	**$27,125**

*These are proposed creeks with at least one alternate site
A – these are alternate creeks

6.3 Cost of laboratory analysis by stream for FY08-09

Creek	All Sites	Proposed Sites Only
Lagunitas	$5,265	$5,265
Olema	$13,295	$11,550
Upper Redwood	$5,580	$4,545
Lower Redwood	$10,030	$7,460
West Union	$4,400	$2,480
	$38,570	**$31,300**

Table 6.4 Estimated Budget

Source of Funding or Expense	Budget	Expenses
WRD	$69,000	
I&M (Freshwater Quality)	$20,000	
Personnel GS-7/4		$45,000
Vehicle		$4,500
Equipment and Supplies		$4,500
Travel		$1,000
Lab Contracts		$34,000
TOTAL	$89,000	

Personnel costs cover a GS-7 full time, term subject-to-furlough position. Travel covers local network travel, bridge tolls, and overnight stays for PINN. Equipment and supplies costs include the purchase of continuous loggers, replacement/repair of YSI 85 multiparameter probes and Oakton pH meters, and repair and calibration of existing flow meters. However, these items may be difficult to purchase with the existing budget. YSI 85 multiparameter probes generally last about 5 years and cost $1,000. Minisondes or datasondes that are deployed to determine diurnal variability are $4,000-$10,000 depending on the sensors that are attached. Sensors for basic core parameters are standard. Additional sensors for nitrate, ammonia, and turbidity add additional costs. Calibration thermometers required by USGS methods (see SOP #5) are approximately \$300. These start-up equipment costs are significant for FY06.

Laboratory contracts will cover the cost of analyses for nutrients, fecal indicator bacteria, and potentially total suspended solids. Approximate costs for laboratory analyses are outlined in Table 6.1 for each parameter method. Further research into additional labs will determine if these costs are realistic for the desired detection limits (see SOP #4).

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Appendix A

Table: Beneficial Uses of the SFAN Water Bodies

Beneficial Uses of individual the SFAN water bodies as determined by the San Francisco Bay RWQCB (with modifications/additions by the SFAN staff in an April 2003 Memo to the RWQCB) are listed in the table below. Sets of water bodies grouped together with similar shading are located within the same greater watershed. Chalone Creek is located within the jurisdication of the Central Coast Regional Water Quality Control Board; however, it is not included in there list of streams. Potential beneficial uses are indicated by "P", existing beneficial uses are indicated by "E".

	Park	AGR	COLD	COMM	EST	FRSH	GWR	IND	MAR	MIGR	MUN	NAV	PROC	RARE	REC1	REC2	SHEL	SPWN	WARM	WILD
Tomales Bay	PORE GOGA	E	E	E	E		E			E	E	E		E	E	E	E	E		E
Lagunitas Creek	GOGA	E	E				E			E	E			E	E	E		E	E	E
Bear Valley Creek	PORE		E							E				E	P	E		E		E
Haggerty Gulch	PORE		E							E				E		E		E		E
Olema Creek	PORE	E	E				E							E	E	E		E	E	E
Pacific Ocean	PORE GOGA			E				E	E	E		E		E	E	E	E	E		E
Santa Maria Creek	PORE		E							E				E	P	E		E	E	E
Coast Creek	PORE		E							P				P	E	E		E		E
Alamere Creek	PORE														P	E		E		E
Crystal Lake	PORE														P	E		E	E	E
Arroyo Hondo	PORE		E							P				E	P	E		E		E
Limantour Estero	PORE		E	E	E				E	E				E	P	E	E	E		E
Glenbrook Creek	PORE		E	E	E				E	E				E	P	E		E		E
Muddy Hollow	PORE		E	E	E				E	E				E	P	E		E		E
Kehoe Lagoon	PORE														E	E			E	E
Abbott's Lagoon	PORE								E						E	E			E	E
Drakes Estero	PORE		P	E	E				E	E				E		E	E	E		E
East Schooner Ck.	PORE		P							P				P				P		E
Home Ranch Creek	PORE		E							E				E		E		E		E
Bolinas Lagoon	GOGA			E					E	E		E		E	E	E	E	E		E
Pine Gulch	PORE		E							E				E		E		E		E
McKinnan Gulch	GOGA		E							E				E		E		E		E
Morses Gulch	GOGA		E							E				E		E		E		E
Pike County Gulch	GOGA		E							E				E		E		E		E
Stinson Gulch	GOGA		E				E			E	E			E		E		E		E
Easkoot Creek	GOGA		E							E	E			E		E		E		E
Webb Creek	GOGA		E								E							E		E
Lone Tree Creek	GOGA																			E
Redwood Creek	GOGA	E	E				E			E	E			E	E	E		E		E
Tennessee Valley	GOGA	E	E							E						E		E		E
Rodeo Lagoon	GOGA				E									E		E		E	E	E
Rodeo Creek	GOGA		E											E		E		E		E
Nyhan Creek	GOGA															E			E	E
San Francisco Bay	GOGA			E	E			E	E	E		E	E	E	E	E	E	E		E
West Union Creek	GOGA		E				E			E				E		E		E		E
Lobos Creek	PRES						P			P	E					E		E	E	E
Mountain Lake	PRES						P									E			E	E
San Pedro Creek	GOGA		E							E	E					E		E		E
Alhambra Creek	JOMU		P							P	E			P	P	E		E	E	E

Definitions of Beneficial Uses are included below. These are defined by the San Francisco Bay Regional Water Quality Control Board at http://www.waterboards.ca.gov/sanfranciscobay/basinplan/web/BP_CH2.html accessed July 20, 2005

AGRICULTURAL SUPPLY (AGR)

Uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
The criteria discussed under municipal and domestic water supply (MUN) also effectively protect farmstead uses. To establish water quality criteria for livestock water supply, the Regional Board must consider the relationship of water to the total diet, including water freely drunk, moisture content of feed, and interactions between irrigation water quality and feed quality. The University of California Cooperative Extension has developed threshold and limiting concentrations for livestock and irrigation water. Continued irrigation often leads to one or more of four types of hazards related to water quality and the nature of soils and crops. These hazards are (1) soluble salt accumulations, (2) chemical changes in the soil, (3) toxicity to crops, and (4) potential disease transmission to humans through reclaimed water use. Irrigation water classification systems, arable soil classification systems, and public health criteria related to reuse of wastewater have been developed with consideration given to these hazards.

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE (ASBS)

Areas designated by the State Water Resources Control Board.
These include marine life refuges, ecological reserves, and designated areas where the preservation and enhancement of natural resources requires special protection. In these areas, alteration of natural water quality is undesirable. The areas that have been designated as ASBS in this region are depicted in Figure 2-1. The state Ocean Plan (see Chapter 5) requires wastes to be discharged at a sufficient distance from these areas to assure maintenance of natural water quality conditions.

COLD FRESHWATER HABITAT (COLD)

Uses of water that support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Cold freshwater habitats generally support trout and may support the anadromous salmon and steelhead fisheries as well. Cold water habitats are commonly well-oxygenated. Life within these waters is relatively intolerant to environmental stresses. Often, soft waters feed cold water habitats. These waters render fish more susceptible to toxic metals, such as copper, because of their lower buffering capacity.

OCEAN, COMMERCIAL, AND SPORT FISHING (COMM)

Uses of water for commercial or recreational collection of fish, shellfish, or other organisms in oceans, bays, and estuaries, including, but not limited to, uses involving organisms intended for human consumption or bait purposes.
To maintain ocean fishing, the aquatic life habitats where fish reproduce and seek their food must be protected. Habitat protection is under descriptions of other beneficial uses.

ESTUARINE HABITAT (EST)

Uses of water that support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds), and the propagation, sustenance, and migration of estuarine organisms.
Estuarine habitat provides an essential and unique habitat that serves to acclimate anadromous fishes (salmon, striped bass) migrating into fresh or marine water conditions. The protection of estuarine habitat is contingent upon (1) the maintenance of adequate Delta outflow to provide mixing and salinity control; and (2) provisions to protect wildlife habitat associated with marshlands and the Bay periphery (i.e., prevention of fill activities). Estuarine habitat is generally associated with moderate seasonal fluctuations in dissolved oxygen, pH, and temperatur and with a wide range in turbidity.

FRESHWATER REPLENISHMENT (FRSH)

Uses of water for natural or artificial maintenance of surface water quantity or quality.

GROUNDWATER RECHARGE (GWR)

Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting saltwater intrusion into freshwater aquifers.

The requirements for groundwater recharge operations generally reflect the future use to be made of the water stored underground. In some cases, recharge operations may be conducted to prevent seawater intrusion. In these cases, the quality of recharged waters may not directly affect quality at the wellfield being protected. Recharge operations are often limited by excessive suspended sediment or turbidity that can clog the surface of recharge pits, basins, or wells.

Under the state Antidegradation Policy, the quality of some of the waters of the state is higher than established by adopted policies. It is the intent of this policy to maintain that existing higher quality to the maximum extent possible.

Requirements for groundwater recharge, therefore, shall impose the Best Available Technology (BAT) or Best Management Practices (BMPs) for control of the discharge as necessary to assure the highest quality consistent with maximum benefit to the people of the state. Additionally, it must be recognized that groundwater recharge occurs naturally in many areas from streams and reservoirs. This recharge may have little impact on the quality of groundwaters under normal circumstances, but it may act to transport pollutants from the recharging water body to the groundwater. Therefore, groundwater recharge must be considered when requirements are established.

INDUSTRIAL SERVICE SUPPLY (IND)

Uses of water for industrial activities that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.

Most industrial service supplies have essentially no water quality limitations except for gross constraints, such as freedom from unusual debris.

MARINE HABITAT (MAR)

Uses of water that support marine ecosystems, including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

In many cases, the protection of marine habitat will be accomplished by measures that protect wildlife habitat generally, but more stringent criteria may be necessary for waterfowl marshes and other habitats, such as those for shellfish and marine fishes. Some marine habitats, such as important intertidal zones and kelp beds, may require special protection.

FISH MIGRATION (MIGR)

Uses of water that support habitats necessary for migration, acclimatization between fresh water and salt water, and protection of aquatic organisms that are temporary inhabitants of waters within the region.

The water quality provisions acceptable to cold water fish generally protect anadromous fish as well. However, particular attention must be paid to maintaining zones of passage. Any barrier to migration or free movement of migratory fish is harmful. Natural tidal movement in estuaries and unimpeded river flows are necessary to sustain migratory fish and their offspring. A water quality barrier, whether thermal, physical, or chemical, can destroy the integrity of the migration route and lead to the rapid decline of dependent fisheries.

Water quality may vary through a zone of passage as a result of natural or human- induced activities. Fresh water entering estuaries may float on the surface of the denser salt water or hug one shore as a result of density differences related to water temperature, salinity, or suspended matter.

MUNICIPAL AND DOMESTIC SUPPLY (MUN)

Uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply.

The principal issues involving municipal water supply quality are (1) protection of public health; (2) aesthetic acceptability of the water; and (3) the economic impacts associated with treatment- or quality-related damages.

The health aspects broadly relate to: direct disease transmission, such as the possibility of contracting typhoid fever or cholera from contaminated water; toxic effects, such as links between nitrate and methemoglobinemia (blue babies); and increased susceptibility to disease, such as links between halogenated organic compounds and cancer.

Aesthetic acceptance varies widely depending on the nature of the supply source to which people have become accustomed. However, the parameters of general concern are excessive hardness, unpleasant odor or taste, turbidity, and color. In each case, treatment can improve acceptability although its cost may not be economically justified when alternative water supply sources of suitable quality are available.

Published water quality objectives give limits for known health-related constituents and most properties affecting public acceptance. These objectives for drinking water include the U.S. Environmental Protection Agency Drinking Water Standards and the California State Department of Health Services criteria.

NAVIGATION (NAV)

Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

INDUSTRIAL PROCESS SUPPLY (PROC)

Uses of water for industrial activities that depend primarily on water quality.

Water quality requirements differ widely for the many industrial processes in use today. So many specific industrial processes exist with differing water quality requirements that no meaningful criteria can be established generally for quality of raw water supplies. Fortunately, this is not a serious shortcoming, since current water treatment technology can create desired product waters tailored for specific uses.

PRESERVATION OF RARE AND ENDANGERED SPECIES (RARE)

Uses of waters that support habitats necessary for the survival and successful maintenance of plant or animal species established under state and/or federal law as rare, threatened, or endangered.

The water quality criteria to be achieved that would encourage development and protection of rare and endangered species should be the same as those for protection of fish and wildlife habitats generally. However, where rare or endangered species exist, special control requirements may be necessary to assure attainment and maintenance of particular quality criteria, which may vary slightly with the environmental needs of each particular species. Criteria for species using areas of special biological significance should likewise be derived from the general criteria for the habitat types involved, with special management diligence given where required.

WATER CONTACT RECREATION (REC1)

Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs.

Water contact implies a risk of waterborne disease transmission and involves human health; accordingly, criteria required to protect this use are more stringent than those for more casual water-oriented recreation.

Excessive algal growth has reduced the value of shoreline recreation areas in some cases, particularly for swimming. Where algal growths exist in nuisance proportions, particularly bluegreen algae, all recreational water uses, including fishing, tend to suffer.

One criterion to protect the aesthetic quality of waters used for recreation from excessive algal growth is based on chlorophyll a.

NONCONTACT WATER RECREATION (REC2)

Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Water quality considerations relevant to noncontact water recreation, such as hiking, camping, or boating, and those activities related to tide pool or other nature studies require protection of habitats and aesthetic features. In some cases, preservation of a natural wilderness condition is justified, particularly when nature study is a major dedicated use.

One criterion to protect the aesthetic quality of waters used for recreation from excessive algal growth is based on chlorophyll a.

SHELLFISH HARVESTING (SHELL)

Uses of water that support habitats suitable for the collection of crustaceans and filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport purposes.

Shellfish harvesting areas require protection and management to preserve the resource and protect public health. The potential for disease transmission and direct poisoning of humans is of considerable concern in shellfish regulation.

The bacteriological criteria for the open ocean, bays, and estuarine waters where shellfish cultivation and harvesting occur should conform with the standards described in the National Shellfish Sanitation Program, Manual of Operation.

Toxic metals can accumulate in shellfish. Mercury and cadmium are two metals known to have caused extremely disabling effects in humans who consumed shellfish that concentrated these elements from industrial waste discharges. Other elements, radioactive isotopes, and certain toxins produced by particular plankton species also concentrate in shellfish tissue. Documented cases of paralytic shellfish poisoning are not uncommon in California.

FISH SPAWNING (SPWN)

Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Dissolved oxygen levels in spawning areas should ideally approach saturation levels. Free movement of water is essential to maintain well-oxygenated conditions around eggs deposited in sediments. Water temperature, size distribution and organic content of sediments, water depth, and current velocity are also important determinants of spawning area adequacy.

WARM FRESHWATER HABITAT (WARM)

Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

The warm freshwater habitats supporting bass, bluegill, perch, and other panfish are generally lakes and reservoirs, although some minor streams will serve this purpose where stream flow is sufficient to sustain the fishery. The habitat is also important to a variety of nonfish species, such as frogs, crayfish, and insects, which provide food for fish and small mammals. This habitat is less sensitive to environmental changes, but more diverse than the cold freshwater habitat, and natural fluctuations in temperature, dissolved oxygen, pH, and turbidity are usually greater.

WILDLIFE HABITAT (WILD)

Uses of waters that support wildlife habitats, including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl.

The two most important types of wildlife habitat are riparian and wetland habitats. These habitats can be threatened by development, erosion, andsedimentation, as well as by poor water quality.

The water quality requirements of wildlife pertain to the water directly ingested, the aquatic habitat itself, and the effect of water quality on the production of food materials. Waterfowl habitat is particularly sensitive to changes in water quality. Dissolved oxygen, pH, alkalinity, salinity, turbidity, settleable matter, oil, toxicants, and specific disease organisms are water quality characteristics particularly important to waterfowl habitat. Dissolved oxygen is needed in waterfowl habitats to suppress development of botulism organisms; botulism has killed millions of waterfowl. It is particularly important to maintain adequate circulation and aerobic conditions in shallow fringe areas of ponds or reservoirs where botulism has caused problems.

PRESENT AND POTENTIAL BENEFICIAL USES

SURFACE WATERS

Surface waters in the region consist of freshwater rivers, streams, and lakes (collectively described as inland surface waters), estuarine waters, and coastal waters. Estuarine waters are comprised of the Bay system from the Golden Gate to the regional boundary near Pittsburg and the lower portions of streams flowing into the Bay, such as the Napa and Petaluma rivers in the north and Coyote and San Francisquito creeks in the south.

Inland surface waters support or could support most of the beneficial uses described above. The specific beneficial uses for inland streams include municipal and domestic supply, agricultural supply, industrial process supply, groundwater recharge, water contact recreation, noncontact water recreation, wildlife habitat, cold freshwater habitat, warm freshwater habitat, fish migration, and fish spawning. The San Francisco Bay Estuary supports estuarine habitat, industrial service supply, and navigation in addition to all of the uses supported by streams.

Coastal waters' beneficial uses include water contact recreation; noncontact water recreation; industrial service supply; navigation; marine habitat; shellfish harvesting; ocean, commercial and sport fishing; and preservation of rare and endangered species. In addition, the California coastline within the San Francisco Bay Basin is endowed with exceptional scenic beauty.

Beneficial uses of each significant water body have been identified and are organized according to the seven major watersheds within the region (Figure 2-2). The maps locating each water body (Figures 2-3 through 2-9) and tables keyed to each map (Tables 2-1 through 2-7) describing associated present and potential beneficial uses were produced using a geographical information system (GIS) at the Regional Board. More detailed representations of each location can be created using this computerized version.

The beneficial uses of any specifically identified water body generally apply to all its tributaries. In some cases a beneficial use may not be applicable to the entire body of water, such as navigation in Calabazas Creek or shellfish harvesting in the Pacific Ocean. In these cases, the Regional Board's judgment regarding water quality control measures necessary to protect beneficial uses will be applied.

Appendix B

Table: Water Quality Monitoring Stages

Monitoring Stages of All Water Bodies Within Legislative Boundaries

	Immediate Watershed	Limited Monitoring	Baseline Monitoring	Adaptive Monitoring	Management Action	Restoration
White Gulch	Tomales Bay					
Bear Valley Creek	Lagunitas Creek		NPS			
Haggerty Gulch	Tomales Bay	NPS				
Olema Creek	Lagunitas Creek		NPS	NPS	NPS	NPS/Other
Cheda Creek	Lagunitas Creek		NPS			
Devil's Gulch	Lagunitas Creek		NPS			
Lagunitas	Tomales Bay		USGS			
Tomales Bay*	Tomales Bay	NPS	Other/NPS		Other	
Bass Lake	Pacific Ocean		NPS			
Hagmaier Pond	Olema Creek		NPS			
Vision Pond	Drakes Bay		NPS			
Pelican Lake	Pacific Ocean					
Wildcat Lake	Pacific Ocean					
Pacific Ocean*			NOAA			
Santa Maria Creek	Drakes Bay					
Coast Creek	Drakes Bay					
Alamere Creek	Pacific Ocean					
Arroyo Hondo	Pacific Ocean					
Crystal Lake	Alamere Creek					
Glenbrook Creek	Limantour Estero	NPS				NPS
Muddy Hollow	Limantour Estero		NPS			NPS
Laguna Creek	Drakes Bay		NPS			
Limantour Estero*	Drakes Bay					
McClure's Creek	Pacific Ocean					
Kehoe Creek	Pacific Ocean		NPS			
Abbott's Creek	Pacific Ocean		NPS			

NOAA – National Oceanic and Atmospheric Association
NPS – National Park Service
USGS – U.S. Geological Survey

Monitoring Stages of All Water Bodies Within Legislative Boundaries (Continued)

	Immediate Watershed	Limited Monitoring	Baseline Monitoring	Adaptive Monitoring	Management Action	Restoration
East Schooner Ck.	Drakes Estero		NPS	NPS		
Home Ranch Creek	Drakes Estero		NPS	NPS		
Creamery Creek	Drakes Estero		NPS			
Drakes Estero*	Drakes Bay	NPS	DHS			
Drakes Bay*	Pacific Ocean	NPS	DHS, others			
A Ranch Perennial	Drakes Bay		NPS			
B Ranch	Drakes Bay		NPS			
C Ranch	Drakes Bay		NPS			
Pine Gulch	Bolinas Lagoon	NPS	Others			
McKinnan Gulch	Bolinas Lagoon	NPS				
Pike County Gulch	Bolinas Lagoon					
Audubon Canyon	Bolinas Lagoon					
Morses Gulch	Bolinas Lagoon	NPS				
Stinson Gulch	Bolinas Lagoon					
Laurel Creek	Bolinas Lagoon					
Black Rock Creek	Bolinas Lagoon		SBWD			
Fitzhenry Creek	Bolinas Lagoon		SBWD			
Easkoot (Table Rock) Creek	Bolinas Lagoon	NPS/Other	SBWD			NPS
Webb Creek	Pacific Ocean	UCB				
Lone Tree Creek	Pacific Ocean	UCB				
Cold Stream	Pacific Ocean	UCB				
Redwood Creek	Pacific Ocean		NPS, UCB, USGS	NPS	NPS	NPS/Other
Green Gulch	Redwood Creek		NPS	NPS		
Kent Creek	Redwood Creek					

DHS-California Dept. of Health Services
NPS – National Park Service
SBWD – Stinson Beach Water District
UCB – University of California, Berkeley
USGS – U.S. Geological Survey

Monitoring Stages of All Water Bodies Within Legislative Boundaries (Continued)

	Immediate Watershed	Limited Monitoring	Baseline Monitoring	Adaptive Monitoring	Management Action	Restoration
Fern Creek	Redwood Creek	USF				
Bootjack Creek	Redwood Creek	USF				
Tennessee Valley	Pacific Ocean		NPS		NPS	NPS
Rodeo Lagoon*	Pacific Ocean	NPS, UCB,	HI			
Rodeo Creek	Rodeo Lagoon	NPS, UCB		NPS	NPS	
Gerbode Creek	Rodeo Creek	UCB				
Nyhan Creek	Coyote Creek	NPS				
Oakwood Valley	Nyhan Creek	NPS				
Coyote Creek	Richardson Bay					
San Francisco Bay*			SFEI, many others			SFEI, others
Franklin Creek	Alhambra Creek	NPS/Other				
Strentzel Creek	Alhambra Creek	NPS				NPS
Crissy Marsh	San Francisco Bay		NPS	NPS		NPS
Lobos Creek	Pacific Ocean		NPS, UWP, Presidio Trust			
El Polin Spring	Sam Francisco Bay	NPS				
Dragonfly Creek	San Francisco Bay		NPS			NPS/Presidio Trust
Tennessee Hollow	San Francisco Bay	NPS	Presidio Trust			
Mountain Lake	Pacific Ocean		NPS/Other			NPS/Presidio Trust
Milagra Creek	Pacific Ocean	NPS/Other				
Calera Creek	Pacific Ocean	NPS, other				

HI – Headlands Institute
NPS – National Park Service
SFEI – San Francisco Estuary Institute
UCB – University of California, Berkeley
USF – University of San Francisco
USGS – U.S. Geological Survey
UWP – Urban Watershed Project

Monitoring Stages of All Water Bodies Within Legislative Boundaries (Continued)

	Immediate Watershed	Limited Monitoring	Baseline Monitoring	Adaptive Monitoring	Management Action	Restoration
Sanchez Creek	Pacific Ocean	NPS				
Laguna Salada	Pacific Ocean					
San Pedro Creek	Pacific Ocean	Other				
San Mateo Creek	San Francisco Bay		SWRCB			
Pilacartos Creek	San Francisco Bay		SWRCB			
Pilacartos Lake	San Francisco Bay		SWRCB			
Stone Dam Reservoir	San Francisco Bay		SWRCB			
San Andreas Lake	San Francisco Bay		SWRCB			
Lower Crystal Springs Reservoir	San Francisco Bay		SWRCB			
Upper Crystal Springs Reservoir	San Francisco Bay		SWRCB			
West Union Creek	San Francisquito Creek	NPS	others			
McGarvey Gulch	San Francisquito Creek	NPS				
Sandy Creek	Chalone Creek		NPS			
Bear Gulch Reservoir	Bear Gulch	NPS				
Bear Gulch	Chalone Creek		NPS			
Chalone Creek	Salinas River		NPS			NPS

NPS – National Park Service
SWRCB – State Water Resources Control Board

Definitions of Monitoring Stages:
No monitoring – all columns are blank; no monitoring has been conducted or information is not available
Limited Monitoring – annual monitoring only; past or current sporadic monitoring, few data points
Baseline Monitoring – seasonal/quarterly or monthly monitoring for at least one year
Adaptive Monitoring – past data has shown elevated levels; source area monitoring was initiated
Management Action - BMPs such as buffer strips and fencing have been implemented
Restoration – past or on-going restoration (e.g., channel or habitat improvement) has occurred or the planning process is underway.

Appendix C

Decision table for the SFAN "Target" Bodies

Decision table for the SFAN target water bodies within NPS legislative boundaries based on WRD Category 1 and Category 2 waterbodies and other criteria. Only wadeable streams are included as target water bodies.

		CATEGORY 1	CATEGORY 2				OTHER	
	Park Unit	**On section 303d list?**	**Lacking Baseline Data?**	**Established Threat?**	**Subject to ecological impairment?**	**Vital Signs Link?**	**Managed by NPS?**	**Other agencies/entities currently monitoring?**
White Gulch	PORE	X*	X				Yes	
Bear Valley Creek	PORE	X*			X		Yes	
Haggerty Gulch	PORE	X*	X				Partial	
Olema Creek	PORE	X*		X	X	X	Yes	
Cheda Creek	GOGA	X*		X		X	Yes	
Devil's Gulch	GOGA	X*		X		X	Yes	
Lagunitas Creek	PORE GOGA	X		X		X	Partial	USGS, SPAWN, and others
Santa Maria Creek	PORE		X				Yes	
Coast Creek	PORE		X				Yes	
Alamere Creek	PORE		X				Yes	
Arroyo Hondo	PORE		X				Yes	
Glenbrook Creek	PORE		X				Yes	
Muddy Hollow	PORE						Yes	
Laguna Creek	PORE						Yes	
McClure's Creek	PORE		X				Yes	
Kehoe Creek	PORE			X			Yes	
Abbott's Creek	PORE			X			Yes	
Home Ranch Creek	PORE			X			Yes	
Creamery Creek	PORE			X			Yes	
A Ranch Perennial	PORE			X			Yes	
B Ranch Creek	PORE			X			Yes	
C Ranch Creek	PORE			X			Yes	
Pine Gulch	PORE				X	X	Yes	
McKinnan Gulch	GOGA		X				Yes	
Pike County Gulch	GOGA		X				Yes	
Audubon Canyon	GOGA		X				No	
Morses Gulch	GOGA		X				Yes	
McKinnan Gulch	GOGA		X				Yes	

** All urban creeks are impaired by diazinon according to the San Francisco Bay Regional Water Quality Control Board
* These water bodies are tributaries of or adjacent to impaired waters but are not themselves listed as impaired
‡ These Presidio water bodies are owned by the Presidio Trust but jointly managed by the Presidio Trust and NPS

Decision table for SFAN target water bodies within NPS legislative boundaries based on WRD Category 1 and Category 2 waterbodies and other criteria. Only wadeable streams are included as target water bodies.

		CATEGORY 1		CATEGORY 2			OTHER	
	Park Unit	On section 303d list?	Lacking Baseline Data?	Established Threat?	Subject to ecological impairment?	Vital Signs Link?	Managed by NPS?	Other agencies/entities currently monitoring?
Stinson Gulch	GOGA		X				Yes	
Laurel Creek	GOGA						Partial	
Black Rock Creek	GOGA						Partial	
Fitzhenry Creek	GOGA						Partial	
Easkoot Creek	GOGA					X	Partial	Stinson Beach Water Agency
Lone Tree Creek	GOGA		X				Yes	
Cold Stream	GOGA		X				Yes	
Webb Creek	GOGA						Yes	
Redwood Creek	GOGA			X		X	Yes	
Green Gulch	GOGA			X		X	Partial	
Kent Creek	GOGA				X	X	Partial	
Fern Creek	GOGA				X	X	Partial	
Bootjack Creek	GOGA				X		Partial	
Tennessee Valley	GOGA			X		X	Yes	
Rodeo Creek	GOGA			X		X	Yes	
Gerbode Creek	GOGA			X		X	Yes	
Nyhan Creek	GOGA	X*			X		Partial	
Oakwood Valley	GOGA	X*					Yes	
Coyote Creek	GOGA	X*	X				Minimal	
Franklin Creek	JOMU	X**		X		X	Minimal	Friends of Alhambra Creek
Strentzel Creek	JOMU		X		X		Partial	
Lobos Creek	PRES	X**		X			Yes	City/County of San Francisco
El Polin Spring	PRES						Yes‡	
Dragonfly Creek	PRES	X**					Yes‡	
Tennessee Hollow	PRES	X**			X		Yes‡	
Milagra Creek	GOGA	X**	X		X		Minimal	
Calera Creek	GOGA	X**	X		X		Minimal	
Sanchez Creek	GOGA	X**	X		X		Minimal	

** All urban creeks are impaired by diazinon according to the San Francisco Bay Regional Water Quality Control Board
* These water bodies are tributaries of or adjacent to impaired waters but are not themselves listed as impaired
‡ These Presidio water bodies are owned by the Presidio Trust but jointly managed by the Presidio Trust and NPS

Decision table for the SFAN target water bodies within NPS legislative boundaries based on WRD Category 1 and Category 2 waterbodies and other criteria. Only wadeable streams are included as target water bodies.

		CATEGORY 1		CATEGORY 2			OTHER	
	Park Unit	**On section 303d list?**	**Lacking Baseline Data?**	**Established Threat?**	**Subject to ecological impairment?**	**Vital Signs Link?**	**Managed by NPS?**	**Other agencies/entities currently monitoring?**
San Pedro Creek	GOGA	X		X		X	No	San Pedro Creek Watershed Coalition
San Mateo Creek	GOGA						No	CA Water Resources Control Board
Pilacartos Creek	GOGA						No	CA Water Resources Control Board
West Union Creek	GOGA	X*	X		X	X	Partial	San Francisquito Creek Watershed Council
Chalone Creek	PINN	X*			X	X	Yes	
Sandy Creek	PINN			X			Yes	
Bear Gulch	PINN					X	Yes	

** All urban creeks are impaired by diazinon according to the San Francisco Bay Regional Water Quality Control Board
* These water bodies are tributaries of or adjacent to impaired waters but are not themselves listed as impaired
‡ These Presidio water bodies are owned by the Presidio Trust but jointly managed by the Presidio Trust and NPS

<u>Category 1 and Category 2 Definitions</u>
Section 303d List – on the Clean Water Act's Section 303d list of impaired water bodies (impaired due to one or more pollutants)
Lacking Baseline Data – no data has been collected for the stream or data is very limited and does not provide enough information to know the baseline condition
Established Threat – monitoring has shown that water quality is compromised due to one or more pollutants
Subject to Ecological Impairment – monitoring has not been conducted or has not shown poor water quality due to pollutants; however, there is potential for impairment
Vital Signs Link- the creek provides habitat for one or more threatened or endangered species (salmonids, CA red-legged frog, San Francisco Garter Snake, CA freshwater shrimp)

<u>Managed by NPS (Category Definitions):</u>
Yes – watershed is located entirely or mostly within park boundaries and is managed by NPS
No – watershed is located within legislative boundary but is managed by other entities
Partial – watershed is partially located within parklands and/or is managed by multiple agencies (e.g., Lagunitas Creek Watershed is managed by NPS, CA State Parks, and the Marin Municipal Water District)
Minimal – watershed is primarily located outside parklands

Appendix D

Table: Specific Monitoring Questions and Related Sample Location

Table: Monitoring Questions for Each Stream

Specific Monitoring Questions and Related Sample Location

	Monitoring question	Habitat	Frequency/Timing*
1	How long does turbidity remain in a stream after a peak storm event?	Riffle/Run	S
2	What percentage of pH observations for each station fall within the numerical objective range of 6.5 – 8.5?	Pool and Riffle/Run	M, C
3	What percentage of all samples exceed the recommended criteria of 0.025 mg/L for ammonia?	Pool and Riffle/Run	M
4	Do the seasonal median concentrations of dissolved oxygen at each station fall below the recommended criteria of 7.0 mg/L (San Francisco Bay Region) or 5.0 mg/L (Central Coast Regiona)?	Pool and Riffle/Run	M, C
5	Based on the median of seasonal values, what percentage of stations meet the fecal coliform criteria for non-contact recreation (2000 MPN/100mL)?	Pool and Riffle/Run	M
6	What is the seasonal and annual variability in pH, D.O., conductivity, and temperature based on monthly samples over a year?	Pool and Riffle/Run	M
7	What is the diel, seasonal, and annual variability in pH, D.O., conductivity, and temperature based on continuous 15-minute readings over a year?	Pool	C
8	Is there a significant relationship between turbidity and Total Suspended Solids or Suspended Sediment Concentration during a storm event?	Pool and Riffle/Run	M, S
9	Is there a significant relationship between conductivity and fecal coliforms annually and during each season?	Pool and Riffle/Run	M
10	What is 30-day average flow-weighted fecal coliform load to Tomales Bay during the winter?	Riffle/Run	M, W
11	Does the 30-day average log mean fecal coliform concentration exceed 200MPN/100mL (criteria for contact recreation) based on five consecutive weeks of sampling in the summer or winter?	Pool and Riffle/Run	M, W
12	What percentage of samples exceed the log mean total coliform concentration of 1000MPN/100mL (criteria for contact recreation) seasonally and annually?	Pool and Riffle/Run	M
13	What is the average annual and seasonal fecal coliform load contribution from each tributary?	Riffle/Run	M
14	What is the maximum fecal coliform concentration at each monitoring station?	Pool and Riffle/Run	M
15	What are the existing nutrient levels and how do they compare to recommended criteria for nitrate, ammonia, and Total nitrogen?	Pool and Riffle/Run	

M=monthly
W=weekly
C=continuous
S= storm event

*The storm event (first, second third; early/mid/late season) will be established during the first year of monitoring. The time of day that sampling occurs will also be established during the first year of monitoring. Subsequent sampling years will mimic the initial monitoring year with regards to storm event and time of day.

Monitoring Questions for Each Stream

This table include priority and alternative streams as well as proposed and alternate sites. For all streams, question #'s 1-5,12,and 14-17 from the "Decision Table for Site Selection" will be addressed. The table denotes additional questions to be addressed at each stream.

Stream/Watershed	Monitoring question	# Proposed Sites	# Alternate Sites*
Olema mainstem	6,7,8,9,10, 11	4	
John West Fork	11, 13	1	
Davis Boucher	11, 13	1	
Quarry Gulch	11, 13		1
Giacomini Gulch	11, 13		1
Home Ranch Creek	9,11		1
East Schooner Creek	9,11		1
Pine Gulch	6, 7	3	
Bear Valley Creek	10,11, 13	1	
Cheda Creek	13	1	
Devils Gulch	13	1	
Green Gulch	13	1	1
Golden Gate Dairy Trib	13	1	
Redwood Mainstem	6,7,8,9	3	
Banducci Creek	13		1
Kent Creek	13	1	
Camino del Canyon	13	1	
Fern Creek	6, 13	1	1
Bootjack Creek	6, 13	1	
Gerbode Creek	13	1	
Rodeo Creek	6, 7, 9	1	1
Tennessee Creek	6, 7, 9	2	1
Nyhan Creek			1
Oakwood Creek			1
Sandy Creek	13	2	2
Bear Gulch	13	1	
Chalone mainstem	7	2	1
Franklin Creek	6, 7	1	
Strentzel Creek	8		5
West Union Creek	6, 8	2	3
Total # of sites		**33**	**22**

*Proposed sites will be monitored; alternate sites are important but may not be a part of the long term plan (i.e., they may be monitored for a short period and then discontinued). Identification of proposed and alternate sites may change as data are analyzed and/or as the water quality program evolves. For some alternate sites, short term monitoring is planned or being conducted by other entities

Appendix E

Table: Water Quality Monitoring Site Location and Access

Table: Site History and Site ID Selection

Site Location and Access Table

Park/ Owner	Stream	Site ID	UTM N	UTM E	Elevation	Access/Directions	Topo Quad (7.5-minute)	Stream Type	Site Type	Permission & Access Notes
PORE	Olema creek	OLM 18	4203441	523220	320 ft	Hwy. 1 MP 21.06; mainstem Olema above Randall Gulch, park in pull-out east of Hwy. 1 near white house	Bolinas	intermittent (perennial pools)	Proposed	
PORE	Olema creek	OLM 14	4205596	521507	200 ft	Northernmost Five Brooks bridge across from park residence; park in large pull-out west of Hwy. 1 adjacent to bridge	Double Point	perennial flow	Proposed	
PORE	Olema creek	OLM 11	4210501	518436	40ft	Upstream of Bear Valley Rd. Bridge; park in pull-out on north side of Bear Valley Rd. (west of creek)	Inverness	perennial flow	Proposed	
PORE	Olema creek	OLM 10B	4212695	516882	20 ft	Below residence #530 (Olema Marsh); park at residence, walk downhill east towards creek (look for path through vegetation towards the left (north); avoid trees and shrubs)	Inverness	perennial flow	Proposed	
PORE	John West Fork	OLM 1	4205293	521706	200 ft	Upstream of Hwy. 1 culvert at MP 22.67; park at pull-out on west side of Hwy. 1 (south of Five Brooks and Ralph Giacomini Ranch), sample at staff gauge	Double Point	perennial flow	Proposed	
PORE	Davis Boucher Creek	OLM 6A	4206897	520260	160 ft	Park at Stewart's Ranch behind barns (northwest side of ranch); follow horse trail and cross Olema; continue along trail (don't cross the footbridge) and cross Davis Boucher; sample above horse trail (50 m upstream of trail bridge)	Inverness	perennial flow	Proposed	Coordinate with park re: private property
PORE	Quarry Gulch	OLM 4	4209737	519021	40 ft	just above confluence with Olema; park at pull-out on west side of Hwy. 1 after cemetery	Inverness	intermittent	Alternate	
PORE	Giacomini Gulch	OLM 2	4205548	521513	200 ft	Hwy. 1 MP 22.78; park at pull-out west of Hwy.1 near John West Fork; sample upstream of culvert	Double Point	intermittent	Alternate	
Private	Pine Gulch	PNG 1	4196963	527051	0 ft	Hwy. 1 to Bolinas Rd., turn left into driveway to sample downstream of road bridge; cross footbridge and access site near stream gauge	Bolinas	perennial flow	Proposed	Coordinate with park re: private property
PORE	Pine Gulch	PNG 2	4199638	524985	120 ft	Park at Olema Valley Trail pull-out on west side of Hwy.1 just north of Dogtown; follow trail then veer off to the west on undesignated trail around north end of wetland, cross the creek, then follow the creek a short distance; sample near stream bend before entrance to the gorge (sample near fish index reach).	Bolinas	perennial flow	Proposed	Contact park hydrologist or fishery biologist for assistance in locating site
PORE	Pine Gulch	PNG 3	4200800	524775	200 ft	Hwy. 1 to Texiera Ranch; enter gate and follow road to the end (past the residence); walk west to the Olema Valley Trail, follow trail, cross the creek twice; sample upstream of horse trail crossing (2nd crossing)	Bolinas	perennial flow	Proposed	Gate key required

Site Location and Access Table (continued)

Park/ Owner	Stream	Site ID	UTM N	UTM E	Elevation	Access/Directions	Topo Quad (7.5-minute)	Stream Type	Site Type	Permission & Access Notes
PORE	Bear Valley Creek	LAG 1	4210696	517655	40 ft	Behind PORE Bear Valley headquarters; adjacent to Roads & Trails yard (downstream of bridge); obtain flow measurement above bridge	Inverness	perennial flow	Proposed	
GOGA	Cheda Creek	LAG 2	4210036	522385	120 ft	upstream of Sir Francis Drake Blvd. MP 19.17	San Geronimo	perennial flow	Proposed	
SPTSP	Devil's Gulch	LAG 3	4209214	523361	120 ft	upstream of Sir Francis Drake Blvd., below Devils Gulch trail (Samuel P. Taylor State Park); access creek past dog walking sign	San Geronimo	perennial flow	Proposed	
Private	Green Gulch	GG north	4190636	537523	< 40 ft	Hwy 1 to Pacific Way; Lower Green Gulch (north), next to horse pasture	Point Bonita	intermittent	Proposed	Coordinate with park re: private property
Private	Green Gulch	GG Control	4191394	538455	160 ft	Hwy.1 to Green Gulch Zen Center; Upper Green Gulch (above Zen Center); near parking lot	Point Bonita	intermittent	Alternate	Coordinate with park re: private property
GOGA	Golden Gate Dairy	GGD culvert	4190940	537395	40 ft	Hwy. 1 across from Muir Beach entrance road (Pacific Way); 5-10 m upstream of Hwy.1 culvert	Point Bonita	intermittent	Proposed	Coordinate with park re: private property
MTSP	Banducci	BAND 1	4191563	536541	< 40 ft	Hwy. 1 to Redwood Creek bridge; take road along Redwood Creek to sample upstream of Banducci culvert (above Redwood Confluence)	Point Bonita	intermittent	Alternate	
MUWO	Redwood Creek	RDW 1	4193545	538056	120 ft	Hwy. 1 to Frank Valley Rd.; Muir Woods concrete bridge above CDC 2, below Muir Woods	San Rafael	perennial	Proposed	
GOGA	Redwood Creek	RDW 3	4191053	537084	40 ft	Above Hwy. 1 bridge (below Banducci)	Point Bonita	perennial; pools in summer	Proposed	
GOGA	Redwood Creek	RDW MuBe	4190393	537396	< 40 ft	Hwy.1 to Pacific Way; just upstream of Muir Beach Pedestrian Bridge	Point Bonita	perennial; pools in summer	Proposed	
MTSP	Kent Creek	KC 1	4192716	537205	120 ft	Frank Valley Rd. to approximately 50 ft above Redwood Creek confluence (above Kent Creek culvert)	San Rafael	intermittent	Proposed	
MUWO	Camino del Canyon	CDC 2	4193508	538100	120 ft	Frank Valley Rd. to Camino del Canyon/Redwood confluence (CDC 1 is above slide)	San Rafael	intermittent	Proposed	

Site Location and Access Table (continued)

Park/ Owner	Stream	Site ID	UTM N	UTM E	Elevation	Access/Directions	Topo Quad (7.5-minute)	Stream Type	Site Type	Permission & Access Notes
MUWO	Fern Creek	FC 1	4194958	537077	200 ft	Frank Valley Rd. to Muir Woods parking lot; take main trail past Cathedral Grove; follow Fern Creek Trail; sample above the Fern Creek/Redwood Creek confluence near MUWO/MTSP boundary	San Rafael	intermittent	Proposed	
MTSP	Fern Creek	FC 2	4196588	536615	1000 ft	Panoramic Hwy. MP 3.22; Fern Creek above Panoramic Hwy. culvert in Mt. Tamalpais State Park	San Rafael	intermittent	Alternate	Notify State park, obtain permit
MTSP	Bootjack Creek	RDW 21	4195822	534960	1440 ft	Bootjack Camp above Panoramic Highway in Mt. Tamalpais State Park	San Rafael	intermittent	Proposed	Notify State park, obtain permit
GOGA	Gerbode Creek	ROD 6	4187657	542339	< 40 ft	Hwy. 101 to 1st exit north of Golden Gate Bridge (Sausalito/Alexander Ave.); follow Bunker Rd. west towards Fort Cronkhite; access from Bobcat Trail after road bridge; sample above confluence with Rodeo Creek	Point Bonita	perennial	Proposed	
GOGA	Rodeo Creek	RC 1-750	4187316	542493	< 40 ft	Bunker Rd. to unmaintained road across from Presidio stables; access site through willows; site is upstream of Miwok trail bridge and downstream of stables (stable tributary convergence), approximately 420 m upstream of Gerbode/Rodeo Creek confluence)	Point Bonita	perennial	Proposed	
GOGA	Rodeo Creek	RC 1-2500	4188095	544009	200 ft	Follow Bunker Rd. to park housing just southwest of tunnel; site is approximately 30m upstream of Capehart housing	San Francisco North	perennial	Alternate	
GOGA	Tennessee Creek	TV 1-2615	4190335	541262	260 ft	Hwy. 1 to Tennessee Valley Rd. to end (trailhead parking); 100 m upstream of Old Springs Trails crossing; above Gabino's house, above Miwok stables	Point Bonita	intermittent	Alternate	Coordinate with park re: private property
GOGA	Tennessee Creek	TV 1-2095	4190212	540670	160 ft	Below Miwok stables, 330 meters upstream of Tennessee Valley/Haypress tributary confluence	Point Bonita	intermittent	Proposed	Gate combination required
GOGA	Tennessee Creek	TV 1-1120	4189337	540597	80 ft	2 meters downstream of Backdoor (tributary to Tenn. Valley); access from Tenn. Valley trail	Point Bonita	intermittent	Proposed	Gate combination required
GOGA	Nyhan Creek	NYH 1	4191465	541504	40 ft	Tennessee Valley Rd.; park at pull-out across from Oakwood Valley sign. Sample above Oakwood confluence, below footbridge.	Point Bonita	perennial	Alternate	

Site Location and Access Table (continued)

Park/ Owner	Stream	Site ID	UTM N	UTM E	Elevation	Access/Directions	Topo Quad (7.5-minute)	Stream Type	Site Type	Permission & Access Notes
GOGA	Oakwood Creek	OAK 1	4191470	541561	40 ft	Above culvert near confluence with Nyhan	Point Bonita	intermittent	Alternate	
GOGA	West Union Creek	WU 1	4144676	562565	640 ft	Hwy. 280 South towards Redwood City; Woodside Rd. exit; Woodside west then veer right onto Kings Mountain Rd. to Huddart County park; park at Zwierlein Picinic area, Crystal Springs Trail, cross McGarvey Gulch, right onto Miramontes Trail. Site is on the mainstem in Phleger Estate 1/4mi down the trail from Huddart Co. Park boundary	Woodside	ponded in summer	Proposed	Notify ranger at entrance station
GOGA	West Union Trib. #1	WU 2	4144954	562339	640 ft	Tributary #1 (first tributary upstream of McGarvey Gulch), above Miramontes trail crossing	Woodside	dry in summer	Alternate	Notify ranger at entrance station
GOGA	West Union Trib. #2	WU 3	4145237	561550	640 ft	Tributary#2, (second tributary upstream of McGarvey Gulch); upstream of Raymundo trail bridge	Woodside	dry in summer	Alternate	Notify ranger at entrance station
GOGA	West Union Creek	WU 4	4145512	561055	720 ft	Mainstem; upstream of Trib. #2	Woodside	dry in summer	Alternate	Notify ranger at entrance station
Huddart County Park	McGarvey Gulch	MGG 1	4144415	562513	640 ft	Between trail crossing and confluence with West Union creek (accessible area above large boulders)	Woodside	ponded in summer	Proposed	Notify ranger at entrance station
JOMU	Franklin Creek	FRA 1	4205172	576184	120 ft	I-80 to Hwy. 4 to Martinez; Alhambra Ave (left), to JOMU visitor center; site is upstream of bridge near automatic stream gauge	Briones Valley	intermittent; pools in summer	Proposed	Gate key required for vehicle entry; separate gate combo for foot entry

Site Location and Access Table (continued)

Park/ Owner	Stream	Site ID	UTM N	UTM E	Elevation	Access/Directions	Topo Quad (7.5-minute)	Stream Type	Site Type	Permission & Access Notes
JOMU	Strentzel Creek	STR 1	4203860	575809	260 ft	Alhambra Ave. south past Mt. Wanda, veer right, enter at Strain Ranch; site is just above confluence with 4th N. tributary (counting from east to west	Briones Valley	Ephemeral; small spring-fed tributary	Alternate	Key to Strain Ranch gate, coordinate with park contact re: private property
JOMU	Strentzel Creek	STR 2	4203819	575797	260 ft	4th north tributary (from east to west)	Briones Valley	ephemeral	Alternate	
JOMU	Strentzel Creek	STR 3	4203805	575781	260 ft	3rd south tributary (from east to west)	Briones Valley	ephemeral	Alternate	
JOMU	Strentzel Creek	STR 4	4203594	576341	260 ft	mainstem Strentzel Creek at fire road crossing near Strain Ranch	Briones Valley	ephemeral	Alternate	
JOMU	Strentzel Creek	STR 5	4203759	576711	220 ft	mainstem Strentzel Creek above Alhambra Ave. culvert	Briones Valley	ephemeral	Alternate	
PINN	Sandy Creek	SC 1	4039107	665268	920 ft	I-280 south to San Jose; 101 south to Hwy. 25 to Hollister; Hwy. 25 to PINN (Hwy. 146). Park at Hwy. 146 pull-out near air quality site; site is in creek opposite of air quality site	North Chalone Peak	intermittent	Proposed	
Private	Sandy Creek	SC 2	4039516	665483	1000 ft	In Pinnacles Campground; near park boundary; far southwest side of campground, near restroom leachfield; sample upstream of culvert	North Chalone Peak	intermittent	Alternate	Notify campground (contact park)
Private	Sandy Creek	SC3	4040202	666068	1000 ft	In Pinnacles campground near pump-out station and downstream of restroom (adjacent to leachfield); opposite side of campground as SC 2 (i.e., far north east end); upstream of tributary confluence	North Chalone Peak	intermittent	Alternate	Notify campground (contact park)
Private	McCabe Creek	MC1	4040066	665749	1000 ft	McCabe Canyon above Hwy. 146 culvert; across from Pinnacles campground	North Chalone Peak	intermittent	Proposed	Notify landowner (contact park), gate key required

Site Location and Access Table (continued)

Park/ Owner	Stream	Site ID	UTM N	UTM E	Elevation	Access/Directions	Topo Quad (7.5-minute)	Stream Type	Site Type	Permission & Access Notes
PINN	Bear Gulch	BG 2	4038964	663073	1240 ft	Park at visitor center parking lot; walk to Resource Management bldg.; sample behind the building near footbridge	North Chalone Peak	intermittent	Proposed	
PINN	Chalone mainstem	CHA 1	4038045	665325	920 ft	Hwy. 146 before (east of) East Entrance station; follow fire road to parking area on the right before road crosses creek. Follow pink flagging to site.	North Chalone Peak	intermittent	Proposed	Gate key required; 4x4 may be needed in wet conditions
PINN	Chalone mainstem	CHA 2	4039344	664153	1000 ft	Hwy. 146 Road Bridge to visitor's center; site is downstream of bridge across from fire wayside exhibit and portable toilet	North Chalone Peak	dry summer to fall	Proposed	
PINN	North Fork Chalone	CHA 3	4041178	662881	1080 ft	Hwy. 146 Chalone Picnic Area; pass picnic area for access to North Wilderness trail; site is just upstream of West Fork	North Chalone Peak	dry summer to fall	Alternate	Note: Road along Chalone Creek to be removed in this area

Site History and Site ID Selection

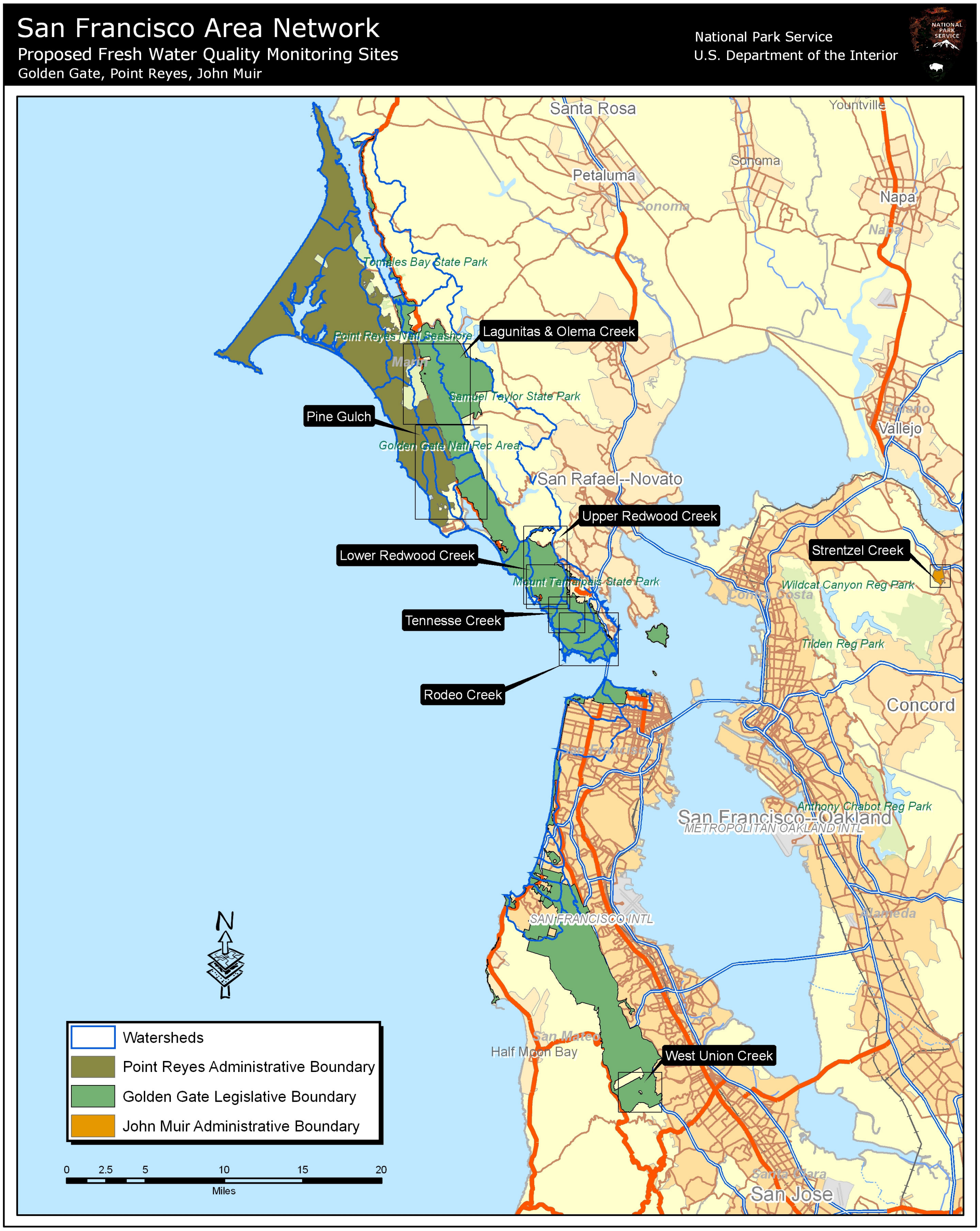
Site ID	Source of site location	Site ID the same?	Notes
OLM 18	PORE on-going database	yes	
OLM 14	PORE on-going database	yes	
OLM 11	PORE on-going database	yes	
OLM 10B	PORE on-going database	yes	
OLM 1	PORE on-going database	yes	
OLM 6A	PORE on-going database	yes	
OLM 4	PORE on-going database	yes	
OLM 2	PORE on-going database	no	This site is entered as OLM 2A in PORE WQ database (OLM 2 was downstream or culvert)
PNG 1	PORE on-going database	yes	near PGL 1 from GGNRA pre-1999 database
PNG 2	SFAN 2004 Macroinvert Sampling	yes	same as macroinvert site
PNG 3	SFAN 2004 Macroinvert Sampling	yes	same as macroinvert site
LAG 1	PORE on-going database	yes	
LAG 2	PORE on-going database	yes	
LAG 3	PORE on-going database	yes	
GG north	stables and Big Lagoon studies	yes	check access since private property (Green Gulch Farm and Zen Center)
GG Control	stables and Big Lagoon studies	yes	check access since private property (Green Gulch Farm and Zen Center)
GGD culvert	GGNRA pre-1999 database, stables studies	no	similar to GGD 3 (RDW-4-1), but away from culvert affects
BAND 1	GGNRA pre-1999 database	yes	near "Banducci" site in 2004 USF (J.Lendvay) study; near Station 9 in 1994 USF (Leach, Podlech,Brown) study "Redwood Creek: Banducchi Bridge"
RDW 1	GGNRA pre-1999 database, USF studies	yes (pre-99 database)	close to Station 2 in USF Podlech, Brown, & Karentz study (1994) and Station 10 in USF Leach, Podlech, & Brown (1997)
RDW 3	GGNRA pre-1999 database	yes	
RDW MuBe	GGNRA pre-1999 database, stables and Big Lagoon studies, USF studies	no	RDW 22, Ped Bridge @ Muir Beach, Redwood Creek at Muir Beach Parking Lot, "Muir Beach" in J. Lendvay, 2004 (USF)
KC 1	GGNRA pre-1999 database	yes	
CDC 2	GGNRA pre-1999 database	yes	
FC 1	University of San Francisco (USF) studies	no	(USF - M. Podlech, 1994);Station 11 ("Fern Creek at the mouth, in Muir Woods"
FC 2	University of San Francisco (USF) studies	no	USF - Jack Lendvay, 2004; "Fern Creek" site name
RDW 21	GGNRA pre-99 database; University of San Francisco (USF) studies;	yes, pre-99 database	USF - Jack Lendvay, 2004; "Bootjack Creek" site name and USF - Podlech, Brown, & Karentz, 1994; Station 3 ("Redwood Creek headwaters at Bootjack Camp")
ROD 6	GGNRA pre-1999 database	yes	
RC 1-750	GGNRA stables studies, SFAN 2004 monitoring; USF	yes, stables study	RC 1-750; Station 3 in (Leach, Podlech, and Brown, 1997)

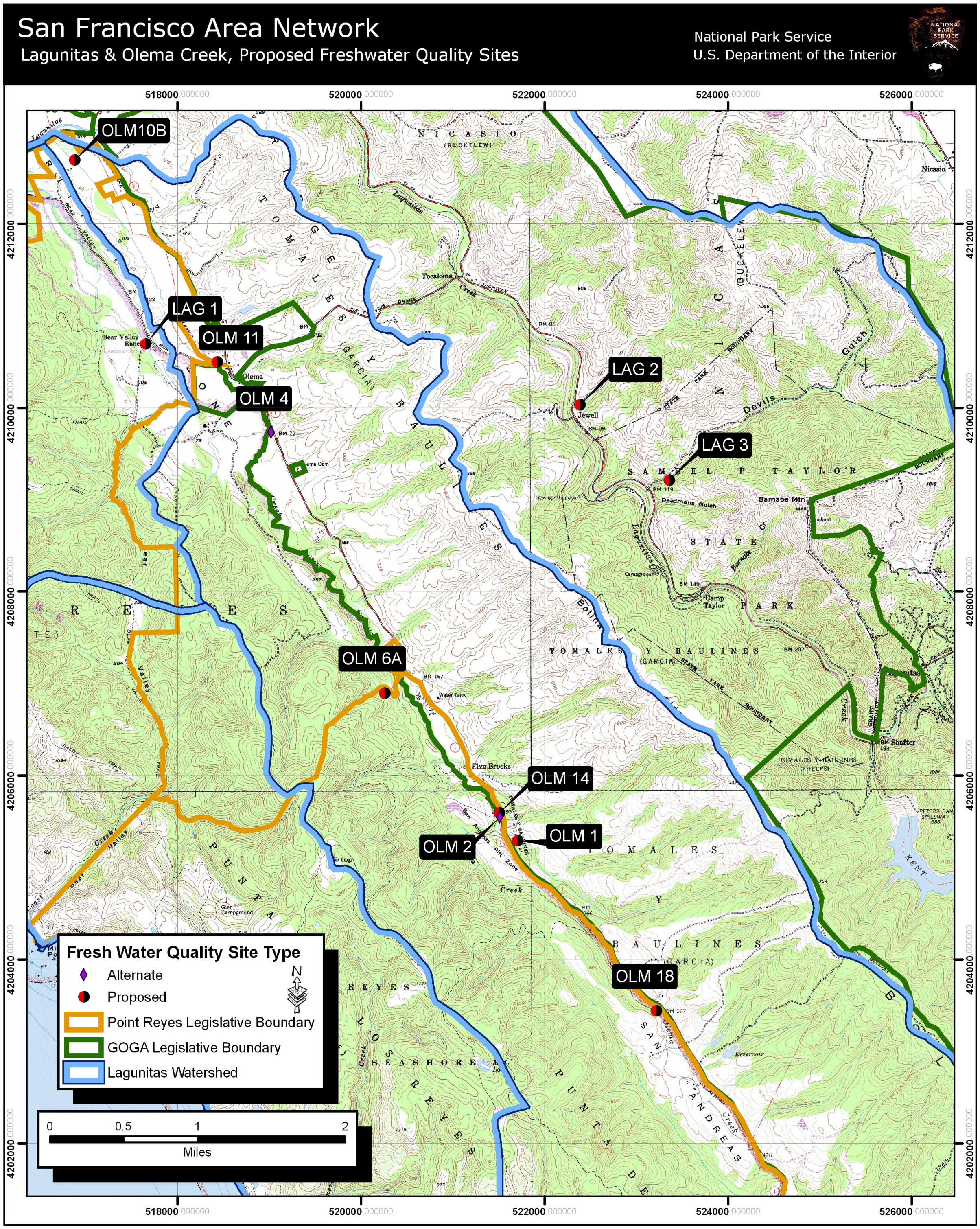
Site History and Site ID Selection (continued)

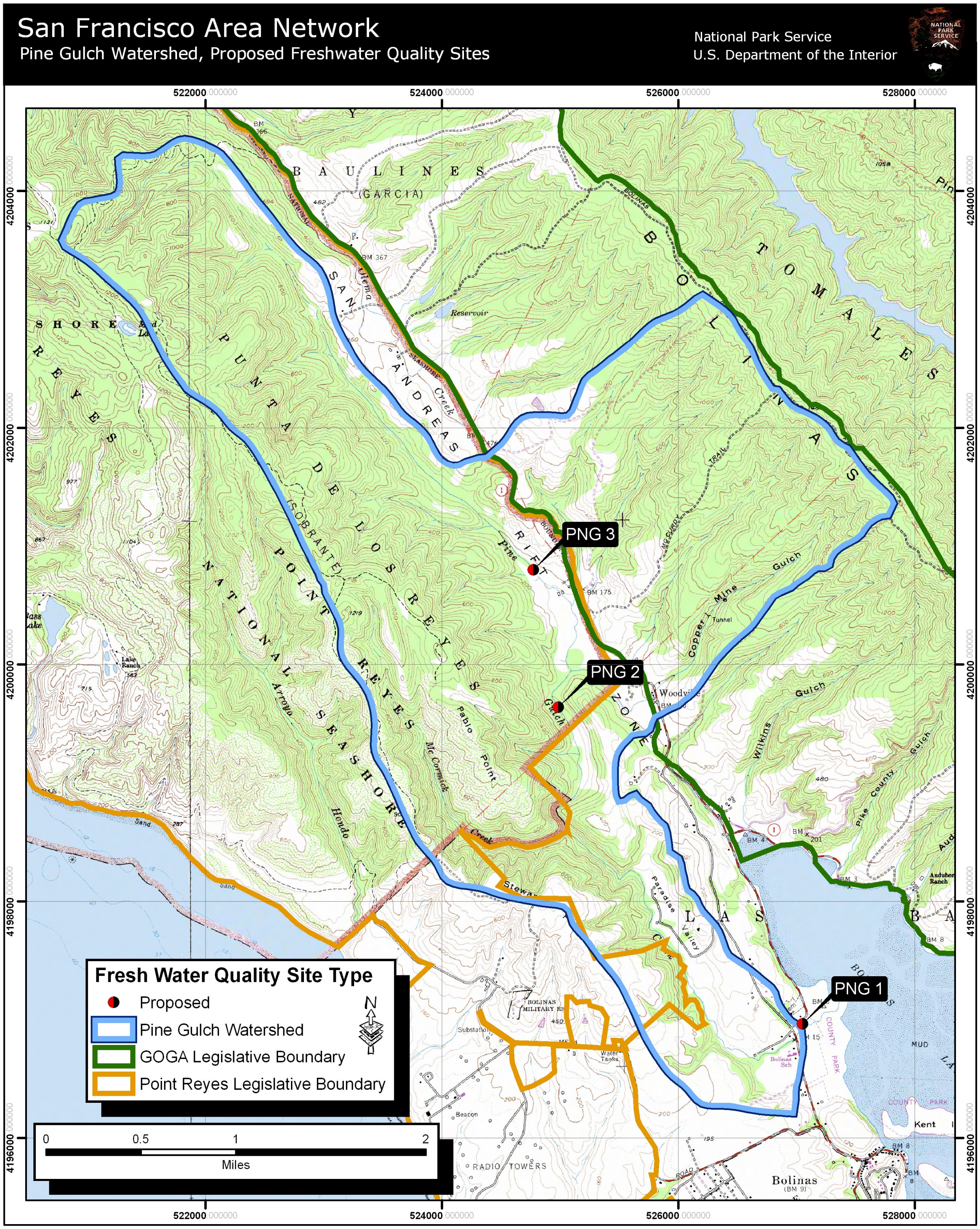
Site ID	Source of site location	Site ID the same?	Notes
RC 1-2500	GGNRA pre-1999 database, stables studies	yes, stables study	ROD 20, RC-1-2500, RC Control
TV 1-2615	GGNRA pre-1999 database, stables studies	yes, stables study	TV 1-2615 (site access restricted since near private residence?)
TV 1-2095	GGNRA pre-1999 database, stables studies, USF, SFAN 2004 Monitoring	yes (pre-1999 database)	also TV 1-2095 in stables study; Station 6 in USF (Leach, Podlech, and Brown, 1997)
TV 1-1120	GGNRA pre-1999 database, stables studies	yes, from stables study	also TV 8 in pre-1999 database, ; site ID same as SFAN 2004 monitoring
NYH 1	GGNRA pre-1999 database, SFAN 2004 monitoring	No, TV 9	changed name since it is not in the Tennessee Valley watershed
OAK 1	GGNRA pre-1999 database, SFAN 2004 monitoring	No, TV 3	changed name since it is not in the Tennessee Valley watershed
WU 1	SFAN 2004 monitoring	yes	
WU 2	SFAN 2004 monitoring	yes	
WU 3	SFAN 2004 monitoring	yes	
WU 4	new site, (SFAN 2003 recon)		
MGG 1	SFAN 2004 monitoring	yes	
FRA 1	SFAN 2004 monitoring	yes	
STR 1	SFAN 2004 monitoring	yes	
STR 2	SFAN 2004 monitoring	yes	
STR 3	SFAN 2004 monitoring	yes	
STR 4	SFAN 2004 monitoring	yes	
STR 5	SFAN 2004 monitoring	yes	
SC 1	PINN 1997-2002 monitoring, SFAN 2004 monitoring	yes	Same as SFAN 2004 monitoring
SC 2	new PINN site 2005 (assistance from SFAN)	Yes	Same as 2005 site
SC3	new PINN site 2005	Yes	Same as 2005 site
MC1	new PINN site 2005	Yes	Same as 2005 site
BG 2	PINN 1997-2002 monitoring, SFAN 2004 monitoring	Yes	Same as SFAN 2004 monitoring
CHA 1	PINN 1997-2002 monitoring, SFAN 2004 monitoring	Yes	Same as SFAN 2004 monitoring
CHA 2	PINN 1997-2002 monitoring, SFAN 2004 monitoring	Yes	Same as SFAN 2004 monitoring
CHA 3	PINN 1997-2002 monitoring	No	"North Fork - approximately 30-40 m upstream of confluence"

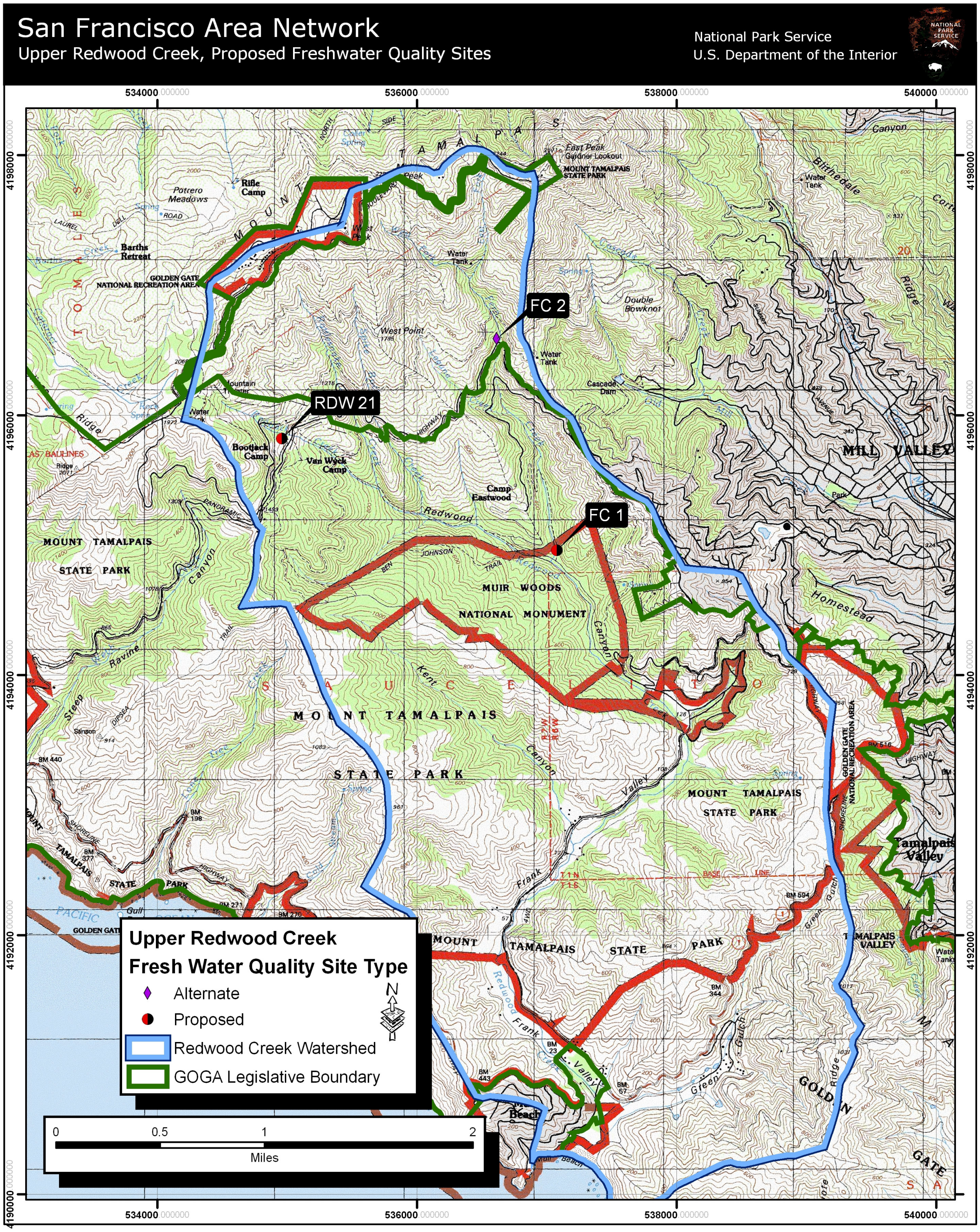
Appendix F

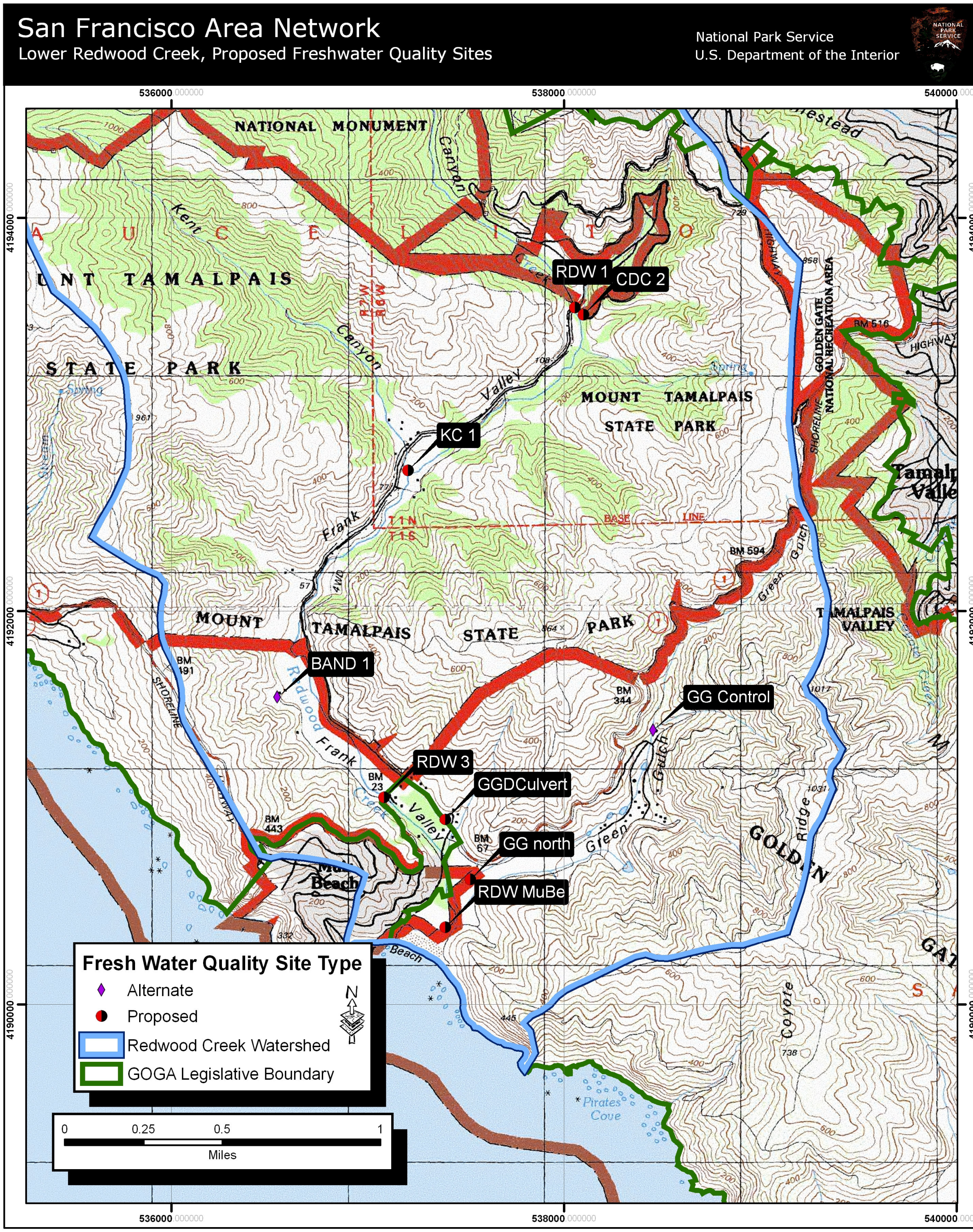
Maps of Watersheds and Sampling Locations

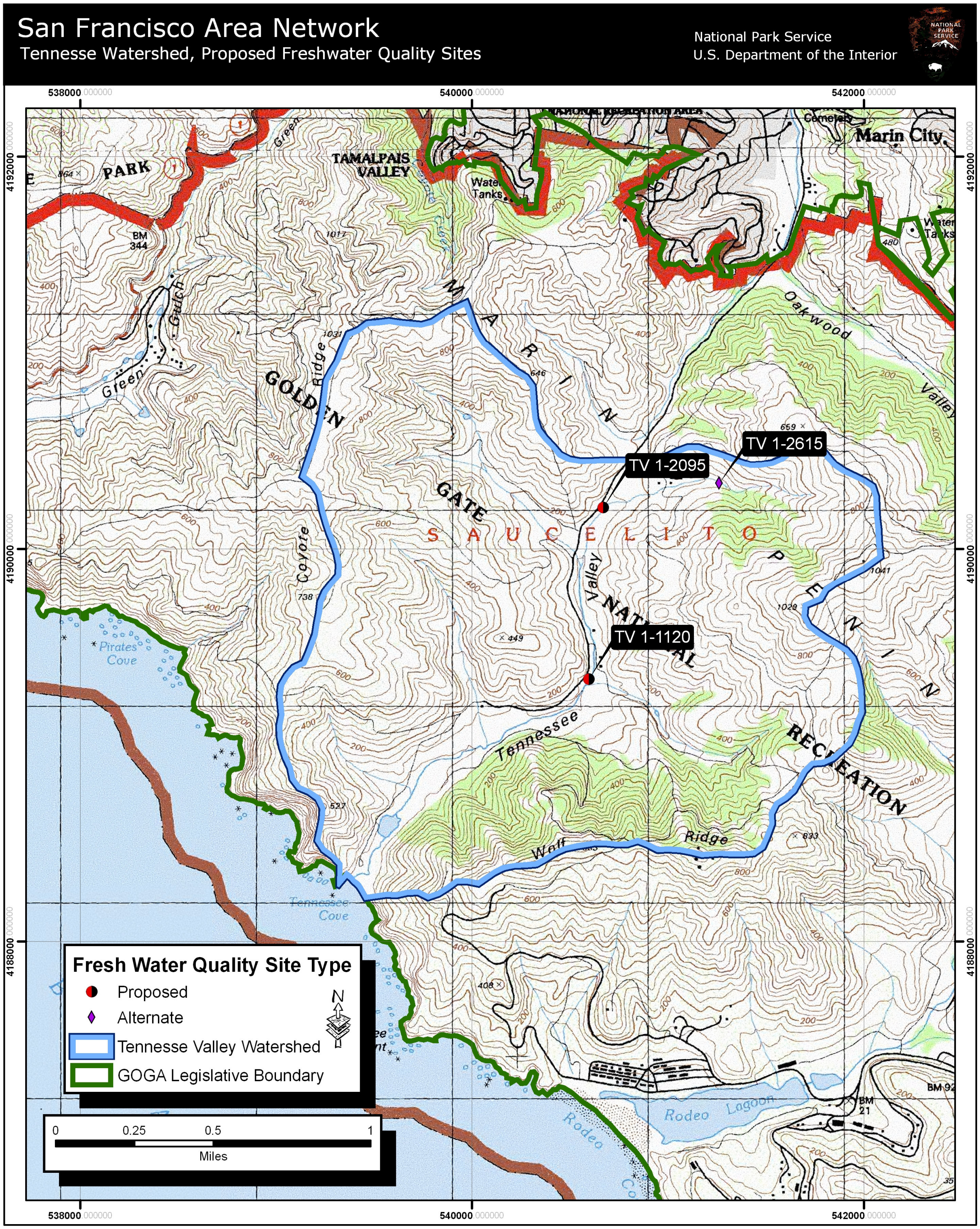

San Francisco Area Network
Proposed Fresh Water Quality Monitoring Sites
Golden Gate, Point Reyes, John Muir
National Park Service
U.S. Department of the Interior
Santa Rosa
Yountville
Petaluma
Sonoma
Napa
Tomales Bay State Park
Point Reyes Nat'l Seashore
Lagunitas & Olema Creek
Samuel Taylor State Park
Pine Gulch
Golden Gate Nat'l Rec Area
Vallejo
San Rafael--Novato
Upper Redwood Creek
Strentzel Creek
Lower Redwood Creek
Mount Tamalpais State Park
Wildcat Canyon Reg Park
Tennesse Creek
Tilden Reg Park
Rodeo Creek
Concord
Anthony Chabot Reg Park
San Francisco--Oakland
METROPOLITAN OAKLAND INTL
SAN FRANCISCO INTL
N
Half Moon Bay
West Union Creek
Watersheds
Point Reyes Administrative Boundary
Golden Gate Legislative Boundary
John Muir Administrative Boundary
0 2.5 5 10 15 20
Miles
San Jose


San Francisco Area Network
Lagunitas & Olema Creek, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
OLM10B
LAG 1
OLM 11
OLM 4
LAG 2
LAG 3
OLM 6A
OLM 14
OLM 1
OLM 2
OLM 18
Fresh Water Quality Site Type
Alternate
Proposed
Point Reyes Legislative Boundary
GOGA Legislative Boundary
Lagunitas Watershed
0
0.5
1
2
Miles
518000
520000
522000
524000
526000
4212000
4210000
4208000
4206000
4204000
4202000

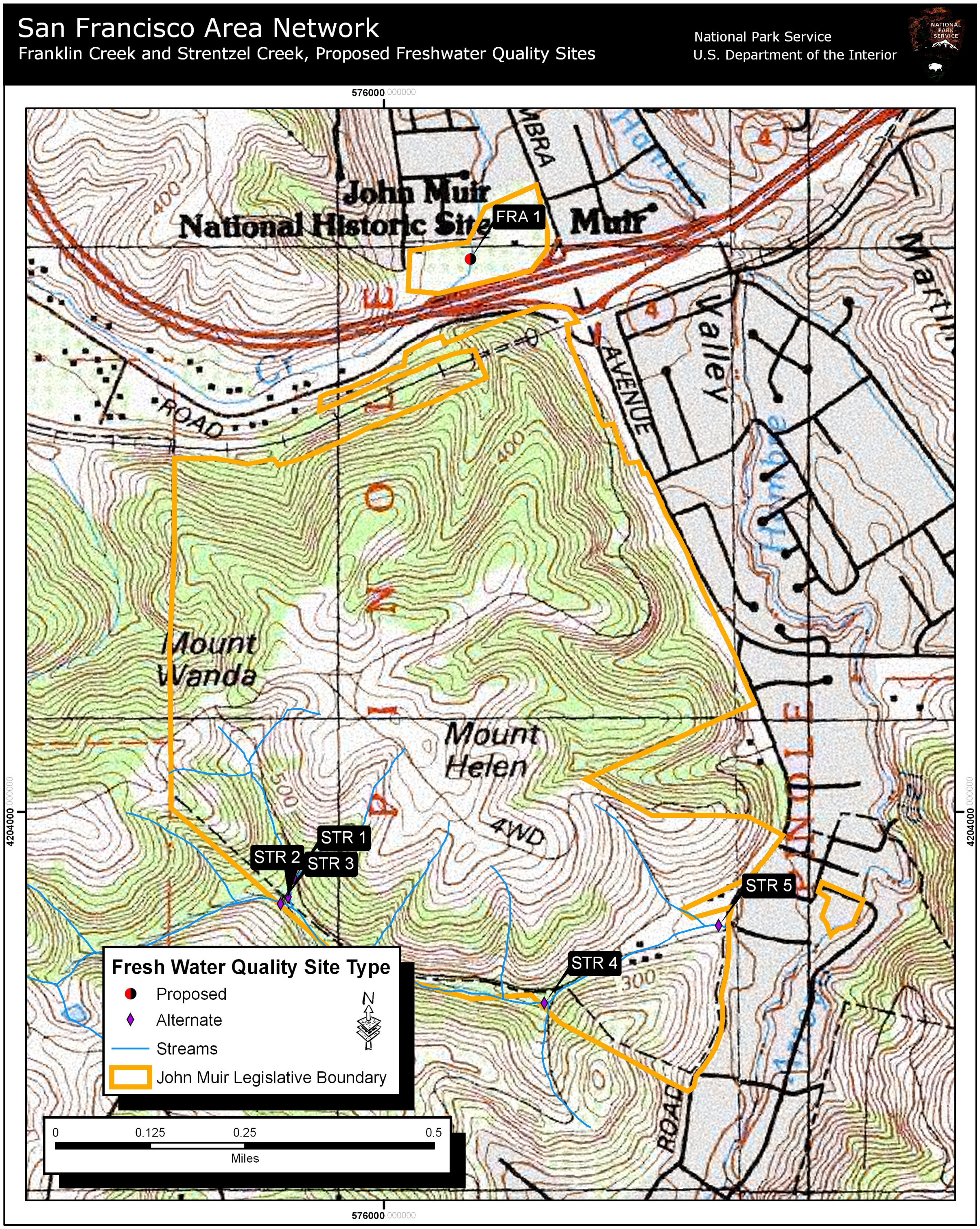

San Francisco Area Network
Pine Gulch Watershed, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
PNG 3
PNG 2
PNG 1
Fresh Water Quality Site Type
Proposed
Pine Gulch Watershed
GOGA Legislative Boundary
Point Reyes Legislative Boundary
0
0.5
1
2
Miles
522000
524000
526000
528000
4204000
4202000
4200000
4198000
4196000

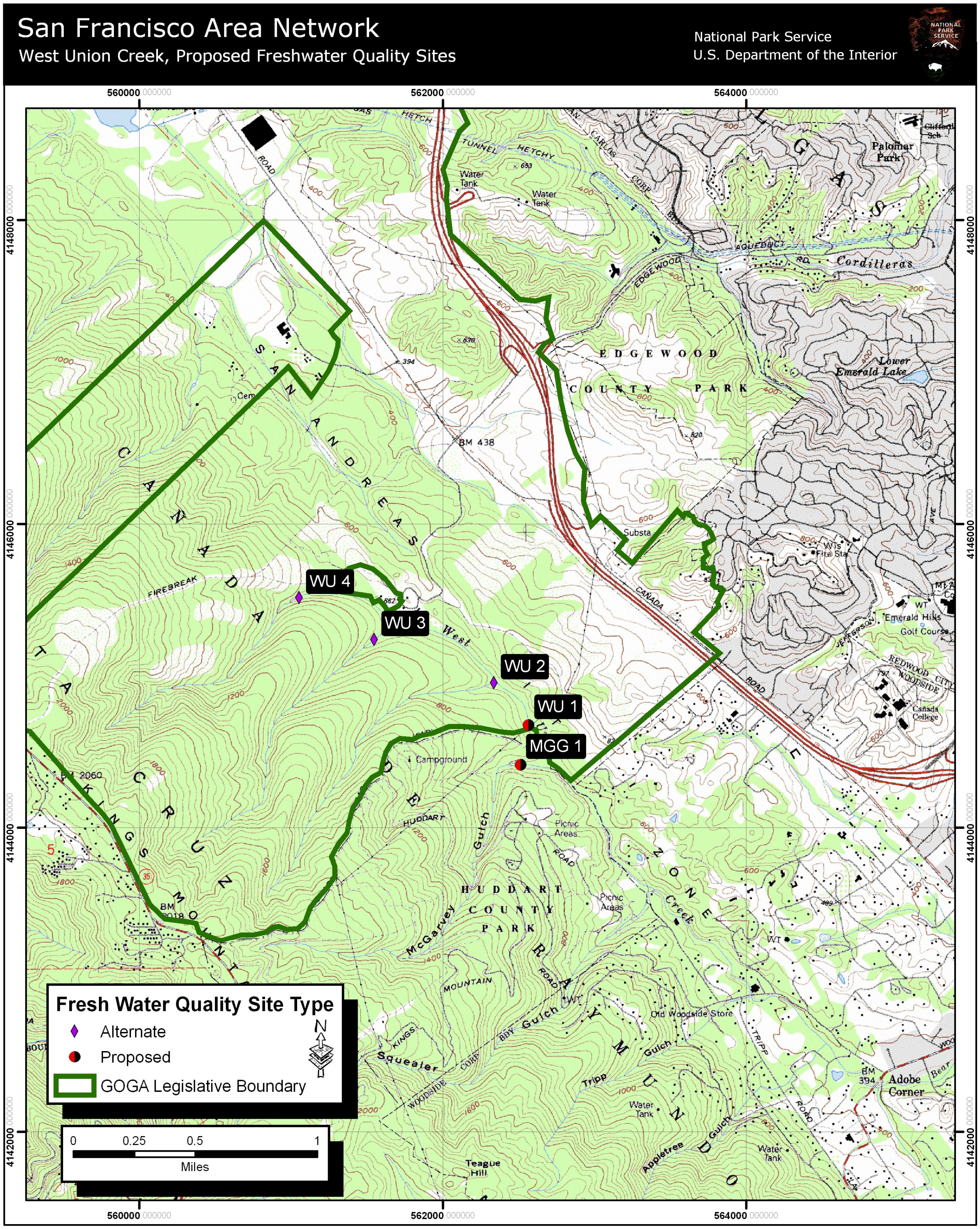

San Francisco Area Network
Upper Redwood Creek, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
FC 2
RDW 21
FC 1
MOUNT TAMALPAIS STATE PARK
MUIR WOODS NATIONAL MONUMENT
MILL VALLEY
Upper Redwood Creek
Fresh Water Quality Site Type
Alternate
Proposed
Redwood Creek Watershed
GOGA Legislative Boundary
0
0.5
1
2
Miles

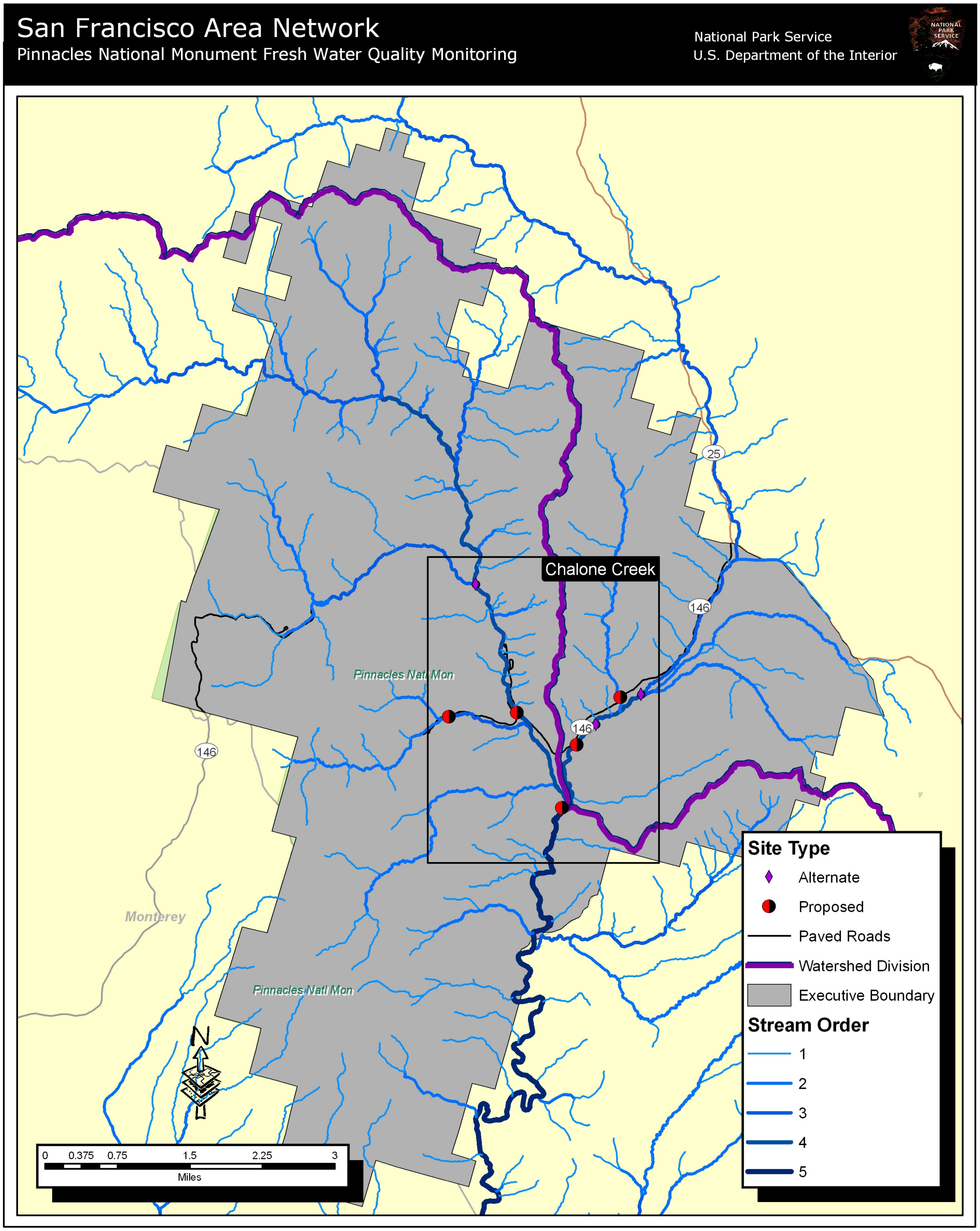

San Francisco Area Network
Lower Redwood Creek, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
536000
538000
540000
4194000
4192000
4190000
RDW 1
CDC 2
KC 1
BAND 1
GG Control
RDW 3
GGDCulvert
GG north
RDW MuBe
NATIONAL MONUMENT
MOUNT TAMALPAIS STATE PARK
GOLDEN GATE NATIONAL RECREATION AREA
TAMALPAIS VALLEY
Fresh Water Quality Site Type
Alternate
Proposed
Redwood Creek Watershed
GOGA Legislative Boundary
N
0
0.25
0.5
1
Miles


San Francisco Area Network
Tennesse Watershed, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
TV 1-2095
TV 1-2615
TV 1-1120
Fresh Water Quality Site Type
Proposed
Alternate
Tennesse Valley Watershed
GOGA Legislative Boundary
0
0.25
0.5
1
Miles
538000
540000
542000
4192000
4190000
4188000
Marin City
TAMALPAIS VALLEY
GOLDEN GATE NATIONAL RECREATION
SAUCELITO
MARIN PENINSULA
Tennessee Valley
Wolf Ridge
Coyote Ridge
Oakwood Valley
Pirates Cove
Tennessee Cove
Rodeo Lagoon

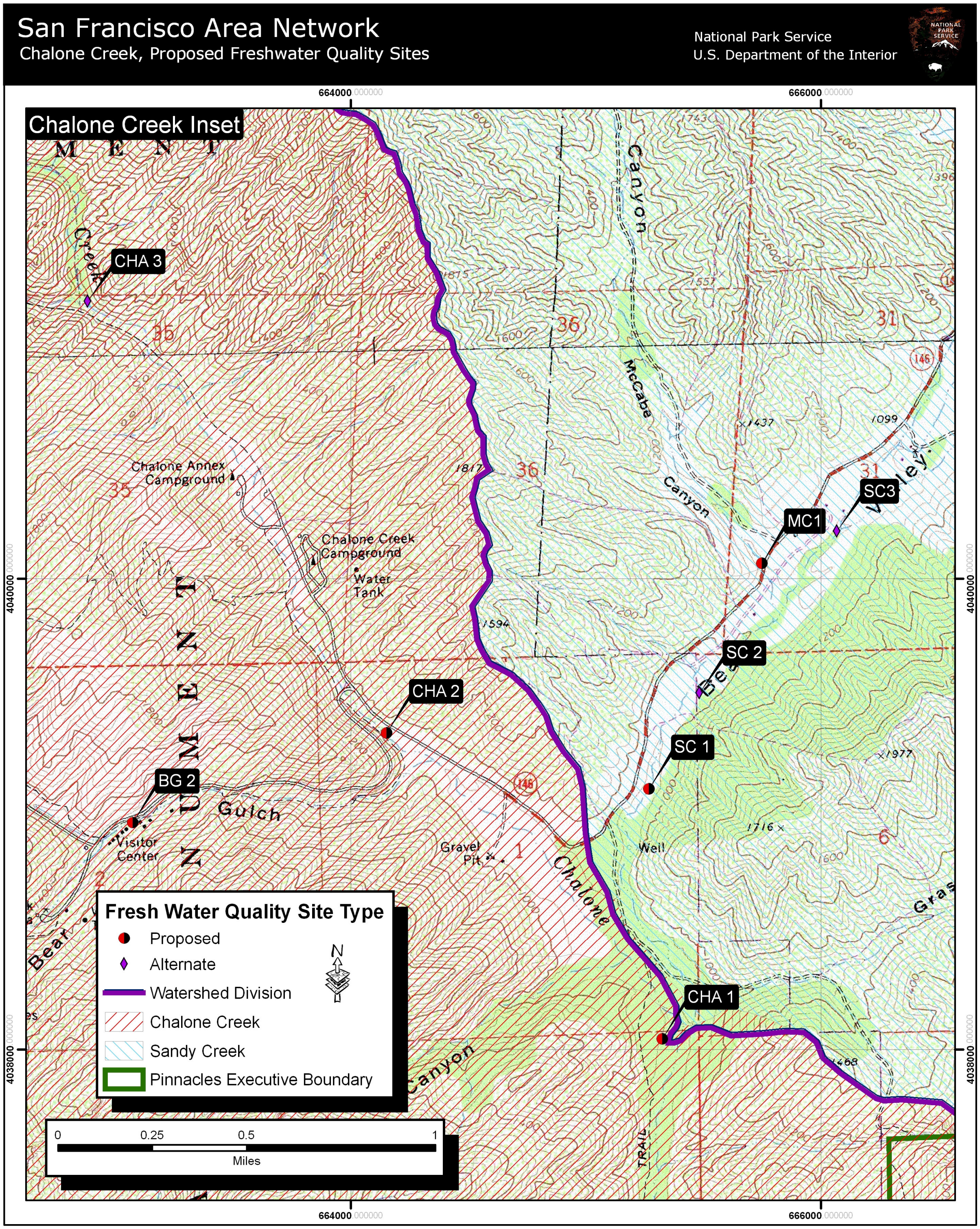

San Francisco Area Network
Rodeo Creek Watershed, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
ROD 6
RC 1-750
RC 1-2500
Fresh Water Quality Site Type
Proposed
Alternate
Rodeo & Rerbode Valley Watersheds
GOGA Legislative Boundary
0
0.25
0.5
1
Miles
540000
542000
544000
546000
4190000
4188000
4186000


San Francisco Area Network
Franklin Creek and Strentzel Creek, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
576000
4204000
John Muir
National Historic Site
Muir
FRA 1
Mount
Wanda
Mount
Helen
STR 1
STR 2
STR 3
STR 4
STR 5
Fresh Water Quality Site Type
Proposed
Alternate
Streams
John Muir Legislative Boundary
0
0.125
0.25
0.5
Miles


San Francisco Area Network
West Union Creek, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
WU 4
WU 3
WU 2
WU 1
MGG 1
Fresh Water Quality Site Type
Alternate
Proposed
GOGA Legislative Boundary
0 0.25 0.5 1
Miles
560000
562000
564000
4148000
4146000
4144000
4142000
EDGEWOOD COUNTY PARK
HUDDART COUNTY PARK
Campground
Cordilleras
Lower Emerald Lake
Emerald Hills Golf Course
Canada College
Adobe Corner
Old Woodside Store
Teague Hill
Palomar Park



San Francisco Area Network
Pinnacles National Monument Fresh Water Quality Monitoring
National Park Service
U.S. Department of the Interior
Chalone Creek
Pinnacles Natl Mon
Pinnacles Natl Mon
Monterey
25
146
146
146
Site Type
Alternate
Proposed
Paved Roads
Watershed Division
Executive Boundary
Stream Order
1
2
3
4
5
0 0.375 0.75 1.5 2.25 3
Miles
N



San Francisco Area Network
Chalone Creek, Proposed Freshwater Quality Sites
National Park Service
U.S. Department of the Interior
Chalone Creek Inset
CHA 3
CHA 2
CHA 1
BG 2
SC 1
SC 2
SC3
MC1
Chalone Annex Campground
Chalone Creek Campground
Water Tank
Visitor Center
Gravel Pit
Well
Gulch
Canyon
McCabe
Chalone
Valley
TRAIL
664000
666000
4040000
4038000
Fresh Water Quality Site Type
Proposed
Alternate
Watershed Division
Chalone Creek
Sandy Creek
Pinnacles Executive Boundary
N
0
0.25
0.5
1
Miles

Appendix G

Metadata Checklist and NPSTORET Database Structure

Metadata Checklist (Tucker, D. personal communication, 14 November 2004.)

Projects:
1) Project ID (8 characters or less)
2) Project Name (60 characters or less)
3) Start Date
4) Project Duration (15 characters or less) - typically this would be something like "Ongoing", "2 Years",
etc.
5) Project Purpose (4000 characters or less)

Stations:
1) Location ID (15 characters or less)
2) Name (60 characters or less)
3) Station Primary Type (Stream/River; Wetland, etc. from STORET Pick List)
4) Station Secondary Type (Only for certain Primary Types: e.g. Canal, CERCLA Superfnd Site, Facility,
Mine/Mine Discharge, Wetland)
5) Decimal degrees latitude/longitude
6) Lat/Lon Method (STORET Pick List)
7) Lat/Lon Datum (STORET Pick List)
8) County
9) State

Metadata:

For every characteristic measured, provide, as appropriate:

1) Official EPA STORET Characteristic Name (STORET Pick List)
2) Your Name for the Parameter/Characteristic
3) Sample Fraction (STORET Pick List)
4) Units
5) Value Type (Actual, Calculated, Estimated)
6) Field/Lab
7) Medium
8) Statistic Type (STORET Pick List)
9) Duration Basis (STORET Pick List)
10) Weight Basis (STORET Pick List)
11) Temperature Basis (STORET Pick List)
12) Particle Size Basis
13) Analytical Procedure - (e.g. Metals in Marine Waters by ICP/MS - EPA/ORD 200.1; Ammonia Nitrogen in Water, Hach 8038)
14) Gear Configuration (name or type of instrument and how it was configured)
15) Sample Collection Procedure/Description (for samples taken to a lab)
16) Sample Handling Procedure (e.g. Cool to 4°C, adjust pH <2 with H_2SO_4)
17) Lab Sample Preparation Procedure (e.g. filtration of water samples, 0.45 microns)

18) Lab Identification and Certification for Characteristic (what lab and was it certified for that characteristic)
19) Detection Limit
20) Lower Quantification Limit
21) Upper Quantification Limit
22) Description/Interpretation of the Limit
23) Lower Range Value (used for warning messages about possible out of range values during data entry)
24) Upper Range Value (used for warning messages about possible out of range values during data entry)
25) Free Text Characteristic/Parameter Description

Metadata Checklist (cont.)

Results:
1) Station ID - one of the previously entered
2) Date
3) Time (optional)
4) Time Zone (required if Time given)
5) Activity/Sample ID
6) Replicate Number (optional)
7) Depth (optional)
8) Depth Units (required if Depth given)
9) Your Name for Parameter/Characteristic
10) Detection Condition (STORET Pick List)
11) Result Value/Text
12) Value Type (Actual, Calculated, Estimated)
13) Value Status (Final, Preliminary)
14) Lab Remarks (STORET Pick List)
15) Detection Limit (if not given in metadata and/or varies with results)
16) Lower Quantification Limit (if not given in metadata and/or varies with results)
17) Upper Quantification Limit (if not given in metadata and/or varies with results)
18) Description/Interpretation of the Limit (if not given in metadata and/or varies with results)

Appendix H

Standard Operating Procedures